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ABSTRACT

A Performance-Based Training (PBT) Qualification Guide/Checklist was developed that would enable a trainee to attain the skills, knowledge, and attitude required to operate the High Flux Beam Reactor at Brookhaven National Laboratory. Design of this guide/checklist was based on the Instructional System Design Model. The needs analysis identified that the skills, knowledge, and tasks required should be standardized. A job and task analysis identified all skills, knowledge, and tasks required for the reactor operator position. During the design phase, these materials were developed: implementation guide, evaluation guide, generic job performance measures, grouping of skills and knowledge, grouping of tasks, and performance-based objectives. Material was developed for each unit of instruction. The skills and knowledge checklist was developed first, followed by tasks required for performance. Additional material included methodology for completion of the guide/checklist, procedural and tickler card guidance, instruction for implementation, evaluation, and sign-off requirements. The guide/checklist was implemented during the small group evaluation trial of five trainees and one shift supervisor. After each phase of evaluation, feedback was used to upgrade the document. Overall reaction was favorable. Trainees and trainer exhibited less frustration since each knew what was expected. (Appendixes, amounting to over two-thirds of the thesis, include the guide/checklist, other support materials developed, and 23 references.) (YLB)

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Thesis/Project

A PERFORMANCE-BASED TRAINING QUALIFICATION GUIDE/CHECKLIST DEVELOPED FOR REACTOR OPERATORS AT THE HIGH FLUX BEAM REACTOR AT BROOKHAVEN NATIONAL LABORATORY

This project was conducted using the principles and techniques of instructional system design (ISD). The document is a report of the designer's plans and experiences in carrying out the design, development, implementation, and evaluation of the project. A plan, budget, analysis of findings, and recommendations are included.

written by

by
Robert C. McNair

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A PERFORMANCE-BASED TRAINING QUALIFICATION GUIDE/CHECKLIST DEVELOPED FOR REACTOR OPERATORS AT THE HIGH FLUX BEAM REACTOR AT BROOKHAVEN NATIONAL LABORATORY

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A Thesis/Project

submitted to The Faculty of the

School of Media and Arts

of The New York Institute of Technology in partial satisfaction
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CHAPTER 1

INTRODUCTION

Overview

In order to achieve certification a reactor-operator trainee must understand and learn basic theoretical concepts, components that make up a system, how individual systems function, and how systems interrelate with each other. This tedious task is usually accomplished within twelve to fourteen months. During this time the trainee learns how to safely, efficiently and effectively operate a machine that is different from any other research machine.

To enable a trainee to attain the skills, knowledge, and attitude required to operate the High Flux Beam Reactor (HFBR) at Brookhaven National Laboratory (BNL), a Performance-Based Qualification Guide/Checklist was developed. Upon successful completion of this Guide, the reactor operator will be proficient in handling routine, as well as, abnormal and emergency plant conditions.

Background

The Brookhaven National Laboratory is operated by Associated Universities, Inc. (AUI) under a prime contract with the Department of Energy. Nine northern universities sponsor AUI. The Board of Trustees consists of two representatives from each university and not more than six Trustees-at-Large. Visiting committees, appointed by AUI, provide a continuing independent evaluation of the research programs carried out by the various scientific departments.

A British physicist, Sir James Chadwick, won the 1935 Nobel Prize for Physics for his discovery of the neutron, one of the particles making up the nucleus of the atom. Since his discovery, neutrons have been studied, not only in themselves, but also as an extremely powerful tool for studying matter on the nuclear, atomic, and molecular level. Neutrons have been used by nuclear and solid state physicists, chemists, and most recently, biologists. As techniques for using neutrons have developed in the various disciplines, there has been an accompanying need for higher levels of neutron flux (density) in order to carry out more complex and sophisticated experiments.

The Brookhaven National Laboratory High Flux Beam Reactor was designed to meet this need, providing a total flux (neutron density) of 2.4×10^{15} neutrons/cm^2-sec. at a power of 60 megawatts thermal.

The HFBR first achieved criticality (a self-sustained chain reaction) on October 31, 1965. The HFBR took approximately four years to build, and was available for experimental use at full power several months after initial criticality.

The HFBR uses highly enriched uranium fuel (U-235) and heavy water (deuterium) as a moderator to sustain a controlled nuclear reaction. The reactor core consists of fuel elements which are constructed with a curved plate design. In each plate uranium oxide (U_3O_8) powder is mixed with the aluminum cladding. The cladding acts as a barrier or containment for the highly radioactive isotopes formed as fission products during the chain reaction.

The reactor vessel is shaped cylindrically on the top and spherically on the bottom. The sphere houses the fuel elements in a cylindrical arrangement. Heavy water is circulated through the space between the fuel plates to remove heat generated from fission. The heat produced by fission is transferred to a heat exchanger (cooler) which transfers the heat to the cooling towers. Beam tubes are impregnated around the sphere mid-plane to extract neutrons so that experimenters can perform their complex and sophisticated experiments.

The outside of the reactor vessel is surrounded by a thermal shield which is made of steel and lead bricks and is cooled by water. The thermal shield removes excess heating caused by radiation from the reactor and provides a containment to keep the core covered with heavy water in the event a leak occurs in the reactor vessel.

A biological shield which surrounds the thermal shield protects the reactor operators and experimenters from the radiation produced in the reactor. The biological shield is made of heavy concrete and steel.

The reactor, its auxiliary equipment, and its experimental facilities are contained in a welded steel hemisphere. Air pressure inside the building is maintained slightly lower than atmospheric pressure to ensure that any air leakage is inward rather than outward. Access to the building is provided by a system of air lock doors.

There are nine beam tubes used to extract neutrons for experimenters' use. A beam tube provides a neutron beam whose properties can be varied to accommodate experiments in several different areas of nuclear physics. They include:

1. A tangential beam of exceptional quality featuring high flux and low gamma ray backgrounds
2. A flexible external facility which offers sources for capture studies in the slow neutron
3. A beam used for "time-of-flight" analysis of resonance neutron capture of gamma rays
4. A protein crystallographic station and a membrane station used for single crystal elastic studies
5. A beam used for elastic and inelastic studies of neutron collisions
6. A beam which accommodates small angle scattering for molecular biology
7. A beam used primarily for single crystal inelastic experiments and studying polycrystalline and amorphous samples

8. A beam used for single crystal inelastic neutron scattering experiments
9. A beam which uses cold neutrons for high resolution inelastic neutron scattering studies of single crystal, polycrystalline, or amorphous samples and study monomolecular biological structures

The experimental stations are used to study nuclear physics, inelastic scattering of neutrons, neutron defraction, and biological structure studies. The neutrons are used as probes to study the atomic structure of matter so that people can have a better understanding of what causes certain biological and physical reactions to occur.

Seven vertical thimbles provide a variety of neutron energy spectra for sample irradiations. Thermal or slow neutrons are used primarily for neutron activation analysis ("fingerprinting") unknown substances by artificially induced radioactivity and for the production of special purpose radioisotopes. Due to the high neutron flux available, it is possible to produce highly radioactive samples from small quantities of material (high specific activity), and to produce certain isotopes in quantities unattainable by any other practical means. Fast neutron irradiations are vital to the study of radiation damage in materials and are playing an important role in the program to develop a fusion reactor.

Three of the irradiation thimbles are located in the reflector portion of the reactor, while two are positioned at the core edge, and another two at the core center. The outer thimbles are fitted with a set of reentrant tubes while the other thimbles are flanged to the reactor vessel. Each thimble is connected to a separate D_2O cooling system which circulates a flow downward through the center and upward through the outer annular region of each tube. Samples are placed in aluminum capsules which are lowered to the bottom of the thimbles to be irradiated.

The BNL Reactor Division supports the work of the experimenters by safely operating and maintaining the HFBR. The reactor operates continuously for three weeks, and then shuts down for refueling which takes approximately three days. Once refueled, the reactor is restarted and the cycle continues.

Currently, there are 12 reactor operators and 7 shift supervisors who support the operation of the facility. Each shift is assigned two reactor operators (a console operator at the controls and a roving operator who checks auxiliary equipment), and one shift supervisor. All personnel are assigned to rotating shifts to man the reactor on a twenty four hour basis. A permanent day crew of two reactor operators and one shift supervisor is assigned to perform daily routine maintenance.

Reactor operators and shift supervisors are required to attend quarterly requalification training to maintain their certification. The Training and Procedures Group is responsible for implementing training in accordance with the HFBR Training Plan. This document dictates how training is to be administered and the Department of Energy has approved implementation of the Training Plan.

Initial reactor operator training is also administered by the Training Group. The trainee receives theoretical training in the areas of nuclear physics, reactor physics, thermodynamics, fluid dynamics, classical physics, mathematics, electricity, water chemistry and treatment, heat transfer, instrumentation, and controls. This is followed by an introduction to system fundamentals. After the theoretical training is completed, the trainee is assigned to a certified shift supervisor to perform on-the-job training. While on shift, the trainee must complete a Qualification Guide/Checklist that includes skills and knowledge required for each system, as well as perform procedural tasks. This checklist is used as a guide during the operations training program and is maintained as a permanent record of the training status of each individual. The trainees' performance is evaluated by the shift supervisor and is also documented in the Qualification Guide/Checklist.

When the Qualification Guide/Checklist is completed, the shift supervisor must acknowledge in writing that the trainee is ready to take the written certification exams. Eight written exams must be taken in the following areas:

1. Principals of reactor operation
2. Features of facility design
3. General operating characteristics
4. Instrumentation and controls
5. Safety features
6. Normal and emergency procedures
7. Radiation control and safety
8. Principals of heat transfer and fluid mechanics

Successful completion of the written exams is followed by an oral demonstrative examination. This is followed by an oral walk-through exam during which the trainee is tested on plant procedures, systems, instrumentation, and controls. A 70% passing grade for each individual exam is required with an 80% overall average. Upon successfully completing the written and oral examination, the reactor operator is certified and is assigned to a shift.

Statement of Problem

The Qualification Guide/Checklist used for initial training identified all the system fundamentals, instrumentation and controls, operating procedures, emergency procedures, administrative and maintenance tasks required for certification. This document lacked the identifying components to support the learning process. Therefore, the document gave the trainee an inadequate perception of what knowledge was required. Additionally, each shift supervisor evaluated the competence level of each trainee according to his own set standard. The evaluation method selected to evaluate each task could differ from one shift supervisor to another.

Purpose of the Project

The purpose of this project was to upgrade the reactor operator Qualification Guide/Checklist to: first, standardize all the skills, knowledge, and tasks required for certification; and second, to identify the evaluation methods required to evaluate each skill, knowledge and task.

Definition of Terms

Following are the terms used at the HFBR environment which clarifies understanding of this text:

High Flux Beam Reactor (HFBR)

The HFBR is a research facility owned by the U.S. Department of Energy and operated by Associated Universities, Inc. on the site of the Brookhaven National Laboratory. As a nuclear facility, the HFBR provides research scientists a source of neutrons via beam tubes or vertical thimbles for their sophisticated experiments.

HFBR Operations Procedures Manual

This manual contains the permanent rules, limits, and operating procedures for the operation of the HFBR, its process equipment, and those experimental facilities which are operated by Operations Group personnel.

HFBR Plant Description Manual

This manual was developed as a training manual to provide the HFBR reactor operator or supervisor trainee with an in-depth source of descriptive material on each of the major systems within the HFBR complex.

Performance-Based Training (PBT) Qualification Guide/Checklist

The PBT Qualification Guide/Checklist is an updated Qualification Guide Checklist which includes an implementation guide, uses objectives with action verbs to identify groups of skills, knowledge, and tasks required for performance. Additionally, it includes an evaluation guide to be used by the shift supervisor.

Qualification Guide/Checklist

The Qualification Guide/Checklist is a list of skills, knowledge, and tasks required to be completed for the reactor operator position.

Qualification Guide Checkout

The Qualification Guide Checkout is a performance test based on the PBT Qualification Guide/Checklist.

Reactor Operator

Under supervision, the reactor operator is responsible for, but not limited to, the startup, operation, maintenance, and shutdown of the HFBR. Additionally, the operator operates, maintains, and repairs auxiliary electrical, mechanical, and other related equipment as required, records and interprets data, performs radioactive and non-radioactive sampling, analyzes content and evaluates results, monitors radioactive environment, operates heavy lifting equipment, performs fuel handling operations, adheres to Operating Procedures manual and tickler cards, and assists in training personnel, as required. He also performs additional tasks as required to maintain and operate the HFBR facility effectively and efficiently to safeguard the surrounding community and environment.

Reactor Supervisor

The reactor supervisor is in charge of a shift of reactor operators and reports to the Operations Group Leader. He is responsible for seeing that all work is done on the reactor in accordance with approved procedures and that all work is within approved limits. He has the authority and responsibility to shut down the reactor whenever continued operation clearly is not safe, and he performs additional tasks as required to maintain and operate the HFBR facility effectively and efficiently to safeguard the surrounding community and environment.

Training Plan

The Training Plan sets forth the policy of the BNL Reactor Division (RD) with regard to the selection, training, and retraining of RD personnel associated with the HFBR. The Training Plan has been constructed to comply with DOE Order 5480.6 and, in conjunction with the appended material, describes the nature of the selection, training, and retraining processes. It also assures that the radiation training requirements of DOE Order 5480.11, Radiation Protection for Occupational Workers, are included in each of the RD training programs.

Assumptions

1. The reactor operator Qualification Guide/Checklist is only administered for initial training.

2. The shift supervisor evaluates initial trainee performance.

Limitations

1. The Qualification Guide/Checklist was specifically developed for the HFBR.

2. The trainees are evaluated on motor skills and cognitive knowledge.

Methods and Procedures

The operator's PBT Qualification Guide/Checklist was developed utilizing the Instructional Systems Design model (ISD). This process is broken up into five phases; i.e., analysis, design, development, implementation, and evaluation.

The analysis phase was performed in three parts: first, a needs analysis, then a job analysis, and finally a task analysis. The three parts of this phase identified the training program's strengths and weaknesses. The design phase identified methodology to develop job performance measures; develop performance-based training objectives; standardize skills, knowledge, and tasks; standardize evaluation methods; test strategy and trainee evaluation. The development phase provided material to support the design phase of the ISD model. During implementation each trainee used a Performance-Based Training (PBT) Qualification Guide/Checklist under the guidance of a certified shift supervisor. In the evaluation phase both the trainees' performance and PBT Qualification Guide/Checklist were evaluated.

Analysis

The needs analysis identified that a Performance-Based Training Qualification Guide/Checklist was required. It identified that training material and evaluation methods should be standardized. The job analysis identified the duty areas, as well as the tasks required. The task analysis identified the skills and knowledge required for task performance.

Design

The design phase of this project identified the methodology on how to develop the following material:

1. A generic job performance measure giving guidance to both the trainee and the evaluator
2. Performance-based training objectives to include action verbs
3. A list of skills, knowledge, and tasks to ensure that a standardized competency level is achieved
4. An evaluation standard to determine whether to perform, simulate, observe, or discuss a skill, knowledge, or task
5. A test based on objectives to ensure that the trainee has learned the skills and knowledge prior to performing tasks
6. Documentation to evaluate trainee progress and performance
7. A method to identify tasks not previously identified during implementation

Development

The development phase of this project included the development of the following material:

1. An implementation guide
2. A generic guide to measure job performance
3. A list of all the performance-based objectives with action verbs
4. A list of the skills, knowledge, and tasks required for each system
5. A method to evaluate each skill, knowledge, or task

During this phase the material listed above was critiqued by Subject Matter Experts (SME's) including management personnel, shift supervisors, and reactor operators. Their feedback was used in the development of the PBT Qualification Guide/Checklist.

Implementation - Small Group Evaluation Trial

In a small group evaluation trial the PBT Qualification Guide/Checklist was distributed to five new trainees seeking to qualify as reactor operators and one shift supervisor. Each trainee had to cover the same amount of material. The list of skills and knowledge that each trainee was tested for was identified, and the shift supervisor followed the job performance measures to test each trainee's skills and knowledge on each system. Task implementation was not performed at this time since the trainee must complete all system skills and knowledge prior to performing task. In addition, prior to performing task each trainee is required to take a written comprehensive examination on the skills and knowledge learned.

Implementation - Pilot Test

Implementation under the pilot test incorporated all shift supervisors and all newly assigned trainees within the HFBR. This is currently in progress and evaluation is being fed back on a daily basis. Also, a "Request for Clarification" form is generated whenever documentation cannot be found to support the skill, knowledge, of task required by the Guide.

Evaluation

The shift supervisor lectured each trainee on various plant systems, walked through each plant system, and evaluated them one-on-one using the PBT Qualification Guide/Checklist. This ensured consistency throughout the evaluation process. The final phase included a comprehensive written exam on system fundamentals. .

Summary

Implementation of the PBT Qualification Guide/Checklist effected a change in the behavior of both the trainee and the shift supervisor. The trainee experienced less frustration and greater confidence during the learning process. Prior to using the PBT Guide the shift supervisor relied on his own individual experiences and selected the skills, knowledge, and tasks he felt were important to test. The shift supervisor had also selected the evaluation method with which he felt comfortable. After implementing the PBT Guide the shift supervisor needed to adapt previous methods in order to now train selected skills, knowledge, and tasks, using the new evaluation method outlined in the PBT Qualification Guide.

CHAPTER 2

ANALYSIS

Introduction

Prior to upgrading the reactor operator Qualification Guide three types of analysis were performed: a needs analysis, a job analysis, and task analysis. Plant management and subject matter experts were involved from the project's inception. The HFBR Training Plan and DOE requirements were reviewed to ensure the project did, indeed, meet the criteria of each of the above documents.

The Plant Description Manual, Operating Procedures Manual, tickler cards, Administrative Procedures, job and task analysis performed in 1983, were all reviewed. This information was used to identify the skills, knowledge, and tasks that were selected to be a part of the PBT reactor operator Qualification Guide/Checklist.

Needs Analysis

The training material for trainees consisted of the following material which is Prepared by the Brookhaven National Laboratory Reactor Division.

1. HFBR Qualification Guide/Checklist (1990) - This lists the items that are required to be completed in the Plant Description Manual and the Operating Procedures Manual.
2. HFBR Plant Description Manual (1989) - Learning objectives are listed for each section of this manual. The sections include Administration, Reactor Core, Rules and Limits, Emergency Procedures, System Fundamentals, System Instrumentation, Controls and Interlocks, and Accident Analysis.
3. HFBR Operating Procedures Manual (1989) (1991) - Includes normal, abnormal, and emergency operating procedures.
4. HFBR Technical Specifications (1983) - Includes the bases for system components, instrumentation, trip setpoints, limiting conditions for operation, and surveillance frequency.
5. HFBR Training Plan (1989) - Incorporates the Qualification Guide for all job positions, as well as sites Reactor Division policy regarding the selection and training of personnel.
6. HFBR Administrative Procedures Manual (1988) - Identifies the Reactor Division administrative requirements.
7. HFBR Maintenance Procedures Manual (1987) - Identifies the Reactor Division maintenance requirements.
8. HFBR Radiation Protection Plan (1989) - Establishes guidelines for the Reactor Division regarding radiation exposure and handling of materials.

9. BNL Emergency Response Plan, Part II, Local Emergency Plan HFBR and BMRR (1988) - Delineates the responsibility, authority, and actions of personnel at the HFBR in the event of an emergency.
10. HFBR Tickler Cards (1990) - Controls surveillance and maintenance procedures performed by the Reactor Division personnel.

The following document was prepared by Brookhaven National Laboratory Safeguard and Security Division:

11. HFBR Post Orders and Procedures Manual (1989) - Identifies security procedures and responsibility within the HFBR facility.

The following document was prepared by Brookhaven National Laboratory Safety and Environmental Protection Division:

12. BNL Safety Manual (1990) - Identifies safety, health, and environmental programs, and delineates structure within the Laboratory structure.

The information listed in the existing Qualification Guide covered a great deal of material in general terms but was not specific in addressing the skills, knowledge, and tasks required for the position. This interpretation was left to the experience of the shift supervisor who was assigned as the trainer. It was difficult for the trainee to determine what he needed to know. Different checkouts could be given by individual shift supervisors for any specific system. In addition, the evaluation method used by each of the shift supervisors differed. Evaluations were performed by discussion, observation, simulation, or by actual performance. A need was identified to upgrade the existing Qualification Guide to include: first, standardization of the skill and knowledge required to perform all tasks; and second, standardization of the method used to evaluate each of the skills, knowledge, and tasks.

Job Task Analysis

A job and task analysis was conducted for the reactor operator position. This analysis identified skills, knowledge, and tasks for initial training to be included in the PBT Qualification Guide/Checklist, and identified a preferred standard to evaluate each . The skills, knowledge, and tasks for the Thermal Shield Cooling Water System are identified in the reactor operator PBT Qualification Guide/Checklist are identified in Appendix A.

These skills and knowledge can be summarized as follows for each system:

1. Discuss the purpose
2. Discuss and draw system flowpaths
3. Discuss equipment function
4. Discuss system parameters and characteristics
5. Discuss system instrumentation and controls

6. Discuss component interlocks
7. Locate and discuss instrumentation operation and process variables
8. Discuss instrumentation, alarm setpoints, and trip functions
9. Discuss system interrelations

Target Population Analysis

The target population consisted of reactor operator trainees pursuing certification and shift supervisor trainers. Table 1 lists the experience and education of the HFBR reactor trainees and Table 2 lists the experience and education of the shift supervisor trainer.

Table 1
Experience and Education
HFBR Reactor Operator Trainees

Trainee	HFBR Experience	Education	Major	Nuclear Navy (years)
1	0 years	BS	Nuclear Engr.	0 years
2	0 years	BE	Engineering Science	0 years
3	0 years	BS	Mechanical Engr.	5 years
4	0 years	AS	Applied Science	6 years
5	*11 years	AS	Applied Science	0 years

*2 years Research Coordination Group experience and
9 years Safety and Environmental Group experience

Table 2
Experience and Education
HFBR Shift Supervisor Trainer

Trainer	HFBR Experience	Education	Major	Nuclear Navy (years)
1	11 years	AS	Engr. Science	6

Organizational Constraints

All HFBR reactor operators and shift supervisors are required to attain a "Q" Level security clearance. This security clearance takes approximately 12 to 18 months. While awaiting clearance, trainees must be escorted throughout the facility. This makes it difficult to perform tasks required for certification. Additionally, trainees without "Q" clearance must leave the facility when certain operational evolutions are performed.

The HFBR Training Group lacks a control room simulator where normal, abnormal, and emergency plant conditions can be simulated. Simulation would reinforce the motor and cognitive skills a trainee needs to focus on during all modes of operation. Having a simulator outside the HFBR secured area would allow trainees to perform plant evolutions prior to receiving a security clearance or actual certification.

A trainee may be assigned to a shift supervisor who is training two to three trainees. This minimizes the time allotted each trainee to receive instruction as well as Qualification Guide checkouts. When shift supervisors take vacations, trainees are temporarily assigned to another shift supervisor. It takes time for the trainee to adjust to different training styles and techniques.

Instructional Goal

The instructional goals of the project were twofold: first, to standardize the level of skill and knowledge, and identify tasks required for certification; second, to standardize the method used to evaluate trainee performance. This was accomplished by establishing the following instructional goals:

1. Identify the required skills and knowledge for each specific system.
2. Identify the tasks required for each specific system.
3. Identify the method required to evaluate each skill, knowledge, or task.

Literature, Existing Course and Material Review

A literature search was conducted at the NYIT, Westbury Campus Shure Library, Westbury, New York, and the Emma S. Clark Library, Setauket, New York. A search was also conducted reviewing Institute of Nuclear Power Operations (INPO) and Department of Energy (DOE) training accreditation guides. A search was conducted on various Training and Procedure Group documents which included: Plant Description Manual, Operation Procedures, Training Plan, Technical Specifications, and Administrative Manual. Existing course material is found in Appendix D of the Reactor Operator Certification Guide in the HFBR Training Plan.

Related Theory

Gagne (1972) distinguishes five main types of learning or five varieties of learned capabilities. They are:

1. Verbal information: the facts and organized information that is stored in memory and can be applied in different situations.
2. Intellectual skills: the ability to form concepts, make discriminations, and use rules and principles.
3. Cognitive strategies: the learners' ability to manage his or her own learning process.
4. Motor skills: the ability to perform physical manipulations and operations.
5. Attitudes: the internal dispositions that influence a person's response and choices. Cognitive strategies and motor skills are required to deal with plant normal, abnormal, and emergency operations.

Gagne (1985) states that there is a relation between the phases of learning and the events of instruction. The instructional events represent the functions performed by instruction which support internal learning processes. Long term memory storage is required by the reactor operator. The shift supervisor activities (Gagne's instructional events) are implemented during on-the-job training.

Gagne-Briggs (1974) The structures and processes of learning proposed in the Gagne-Briggs information model identifies performance of learned skills or knowledge. The PBT Qualification Guide/Checklist identifies performance required for skills, knowledge, and tasks.

Mager (1984) states that given any objective in a subject area with which you are familiar, in all instances be able to identify (label) correctly the performance, the conditions, and the criteria of acceptable performance when any or all those characteristics are present.

Kirkpatrick (1987) states that there are four levels of evaluation: reaction to training, learning that took place, change in behavior, and results. All four levels of evaluation are used to monitor the PBT Qualification Guide/Checklist's effectiveness.

Boguslaw (1966) states to understand the operation of large systems, it is necessary to consider something more than the attributes of human beings working within it. Machines, computer programs, and more generally, programs of interaction which can be adopted to achieve a system goal are all involved in the analysis of team behavior.

Edwards (1966) states that any man-made machine system must provide display and controls for the operators. In a system which includes a computer, such interfaces between man and hardware must be very carefully designed.

Literature Review

1. Wiggins, N.A., (1987). Training of OJT Instructors, CSNI Specialist Meeting on Training of Nuclear Reactor Personnel, April 21-24, 1987. This paper was presented at the 1987 Nuclear Training Symposium sponsored by the U.S. Nuclear Regulatory Commission and the National Academy for Nuclear Training held in Orlando, Florida. The author is the Training Manager for the New Hampshire Yankee Seabrook Nuclear Power Station. He states that OJT instructors need to be subject matter experts. The instructor must know the procedures on how to implement and document OJT. Communications and demonstrations of motor skills is an important part of OJT instruction. The instructor must recognize when the trainee has reached the required level of performance. The job performance measures are used to evaluate and document trainee performance.

2. Ikeda, Koichs, (1987). Training Programs for Nuclear Power Plant Personnel, Japan. CSNI Specialist Meeting on Training Nuclear Reactor Personnel, April 21-24, 1987. This article was presented at the 1987 Nuclear Training Symposium sponsored by the U.S. Nuclear Regulatory Commission and the National Academy for Nuclear Training held in Orlando, Florida. The author stated that in the operating administration of Japanese nuclear power plants, the basic policies are as follows:
    a. To secure the complete safety and assure the stable plant operation,
    b. To win the confidence of the local inhabitants and society, and
    c. To promote the efficiency of plant operations.

On-the-job training occurs during all shifts. The operators are organized to form five groups corresponding to four operation shifts with three shifts per day and one shift for daytime work. A daytime work shift is mainly allocated for education and training. Training which occurs during the operation shift covers operation and plant systems. The trainees are instructed by an operator in charge of education for each shift. The daytime work shift is instructed by the chief shift supervisor or the assistant shift supervisor.

Survey of Existing Materials

Institute of Nuclear Power Operations (INPO) Manuals - Gave guidance on how to format a PBT Qualification Guide.

Training Accreditition Program (TAP) Manuals (1989) - Gave guidance on how to format a PBT Qualification Guide.

HFBR Training Plan (1989) - Existing reactor operator Qualification Guide is maintained in this document. This project is based on upgrading this document to eliminate its weaknesses as identified earlier.

HFBR Plant Description Manual (1989) - Identifies a majority of the skills and knowledge for each system. Not all the skill and knowledge statements are incorporated in the document. This document is referenced in the PBT Qualification Guide/Checklist.

HFBR Plant Operating Procedures (1989) (1991) - Identified tasks required. This document is referenced in the PBT Qualification Guide/Checklist.

HFBR Technical Specifications (1983) - Lists all the limits associated with plant operations and surveillance requirements. This document is referenced in the PBT Qualification Guide/Checklist.

HFBR Administrative Manual (1988) - Gives direction on how administrative duties are performed. This document is referenced in the PBT Qualification Guide/Checklist.

HFBR Maintenance Procedures Manual (1987) - Identifies the Reactor Division maintenance requirements.

HFBR Radiation Protection Plan (1989) - Establishes guidelines for the Reactor Division regarding radiation exposure and handling of materials.

BNL Emergency Response Plan, Part II, Local Emergency Plan - HFBR and BMRR (1988) - Delineates the responsibilities, authority, and actions of personnel at the HFBR in the event of an emergency.

HFBR Tickler Cards (1990) - Controls surveillance and maintenance procedures performed by the Reactor Division personnel.

HFBR Post Orders and Procedures Manual (1989) - Identifies security procedures and responsibility within the HFBR facility.

BNL Safety Manual (1990) - Identifies safety, health, and environmental programs within the Laboratory structure and delineates responsibility.

Plan for Design and Development Effort

The reactor operator's PBT Qualification Guide/Checklist was developed between January and November of 1990. During the development phase each reactor system in the Guide was sent to certified reactor operators, shift supervisors and management personnel SME's for evaluation. Minor modifications were made to much of the PBT Qualification Guide/Checklist.

The Qualification Guide was presented to the HFBR Training Curriculum Review Committee for final approval in accordance with Appendix B. The Operations Group representative finalized which tickler card procedures within the Guide were required to be performed for the reactor operator position.

Prior to formal implementation of the PBT Qualification Guide/Checklist a meeting was held with the shift supervisors and reactor operators to instruct them on its implementation, as scheduled in Appendix C.

Estimated Student Effort

It normally takes 12 to 14 months for a reactor operator to complete the PBT Qualification Guide/Checklist. The trainee prepares for a system checkout by reading the learning objectives for each system, studying the Plant Description Manual, and reviewing it with an SME to ensure the proper skill and knowledge outlined in the objectives have been learned. Once the trainee is prepared for a specific system checkout, the PBT Qualification Guide/Checklist is used to document trainee performance.

A comprehensive written examination is taken to ensure that a trainee is proficient. The trainee who has progressed beyond the skills and knowledge level undertakes task performance. The trainee prepares to perform task by simulating procedural steps in the Operating Procedures Manual and then reviewing them with an SME to ensure the task is properly performed.

The PBT Qualification Guide/Checklist outlines the tasks that are required and addresses the evaluation method to be used. Once the task is successfully completed, it is documented in the Guide.

Project Plan

A Gantt chart was used to manage this project as shown Appendix D. The initial project was forecast to be completed in six months; the actual time was seven months. There was a four month interruption during the development of this project due to an additional workload which had higher priority.

Budget

The cost of the PBT Qualification Guide/Checklist was within the budget initially forecast. The costs associated with the project are identified in Table 3. The bottom-line dollar value was $77,396.

Implementation of the pilot test incurs no additional costs since the trainees are participating in the learning process in accordance with the HFBR Training Plan. Also, there are no additional costs associated with the delivery of this project once the PBT Qualification Guide/Checklist is completed.

Table 3
Project Budget

Expenses	**Designer Hours**	**Small Group Trail Hours**	**Additional Hours**	**Cost**
Labor				
Analysis	80			$ 2,400
Design	65			1,950
Development	1261			37,830
Implementation		1440		28,961
Evaluation	52			1,560
Clerical			400	4,375
Materials				
Stationery & Supplies				320
Bottom Line Dollar Value				**$77,396**

Summary

The needs analysis identified the skills, knowledge, and tasks which had to be standardized for the reactor operator trainees. In addition, the shift supervisor needed to standardize the method used to evaluate trainee performance. The job analysis identified the duty areas and grouped the tasks. The task analysis identified the elements, the skills and knowledge required to perform task.

CHAPTER 3

DESIGN

Introduction

The design phase of the project was driven by the analysis phase. The training development plan was established to identify material development and strategies for implementation of the new PBT Qualification Guide/Checklist. The following material was developed and is included in the Guide:

1. Implementation guide - developed to give the trainee and trainer guidance on how to use the PBT Qualification Guide/Checklist.
2. Evaluation guide - developed to instruct the trainee and trainer to select the appropriate evaluation method.
3. Job performance measures - identified the conditions and standards for performance.
4. Grouping of skills and knowledge - grouped and performed prior to task performance.
5. Grouping of tasks - grouped to cover specific duty areas.
6. Performance-based objectives - developed to define the skills, knowledge, and tasks required for evaluation.

Instructional Task Analysis

A needs analysis determined that training monitored by the PBT Qualification Guide/Checklist should accomplish the following training goals:

1. Increase the cognitive knowledge level of both trainers and trainees on the following:
    a. system fundamentals, instrumentation, and controls.
    b. task performance.
2. Increase level of task performance.
3. Establish criteria for evaluation of task performance.

The skills, knowledge, and tasks required for the reactor operator position are included in Appendix A. The tasks required to be performed are covered by specific operating procedures that identify the cognitive knowledge and motor skills which are evaluated by a generic job performance measure.

Instructional Objectives

Before you prepare instruction, before you select instructional procedures or subject matter material, it is important to be able to state clearly just what you intend the results of that instruction to be. A clear statement of instructional objectives will provide a sound basis for choosing methods and materials and for selecting the means for assessing whether the instruction has been successful Mager (1984).

The instructional objectives were developed to cover skills, knowledge and task performance. The cognitive knowledge covered specific system operations, as well as an integrated system response. The motor skills dealt with the man-to-machine interface to perform task in the operator's environment.

Entry Behavior Defined

The HFBR Training Plan identifies, in general terms, the entry skills and knowledge requirements for the reactor operator position. Determination as to whether or not a candidate has the necessary criteria occurs during the interview process prior to job offer and acceptance. Candidates have diversified backgrounds including navy nuclear, power plant operations, non-nuclear military, technological and engineering education, or a combination of any of the above. Line management decides if a potential reactor operator candidate exhibits the required experience, attitudes, knowledge, and behavior which will lead to certification. The criteria used to evaluate trainee performance is referenced in the upper left-hand corner of each PBT Qualification Guide/Checklist. For example, Section 5.4 of the Plant Description Manual (as shown in Appendix A) is the standard used to evaluate the "Thermal Shield Cooling Water System Fundamental Skills and Knowledge." Section 5.4 of the Operating Procedures Manual (as shown in Appendix A) is the standard used to evaluate the "Thermal Shield Cooling Water System Operating Procedure Task."

Group and Sequence Objectives

The PBT Qualification Guide/Checklist objectives were sequenced from simple to complex. The first set covered the skills and knowledge required to perform task. The second set covered actual task performance in accordance with the Operating Procedures Manual. The performance-based objectives are stated in Appendix A for skills, knowledge, and tasks.

Learning Activities Specifications

Each trainee is given a PBT Qualification Guide/Checklist prior to shift assignment. This document is self-explanatory and identifies how it is to be implemented. Each subject area of the document references the appropriate sections of the Plant Description Manual, Operating Procedures Manual, and Administrative Procedures Manual to support the learning activities. Each subject area identifies the PBT objectives which are the learning activity specifications. In addition, the skills, knowledge, and tasks required are identified to support the activities.

Table 4 identifies the content of instructional method and media for each learning activity. In addition, an explanation relating the instructional activities to Gagne's nine steps of instruction is done in Table 5.

Table 4
Learning Activity Instructional Strategy Mix

Learning Activity	Content	Instructional Method	Media
1	System Fundamentals	Lecture/Discussion	Realia
2	System Instrumentation	Lecture/Discussion/OJT	Realia/Models
3	System Controls	Lecture/Discussion/OJT	Realia/Models
4	System Interlocks	Lecture/Discussion/OJT	Realia/Schematics Models
5	System Operations	Observation/Simulation Performance/OJT	
6	System Integration	Lecture/Discussion/OJT	Realia
7	Administration	Lecture/Discussion/OJT	Realia

In addition, Gagne's internal processes and their corresponding instructional events and action examples for the PBT Qualification Guide/Checklist are correlated.

The length of time required to complete the reactor operator PBT Qualification Guide/Checklist varies from 12 to 14 months.

Table 5
Internal Process and Its Corresponding Instructional Events with Action Examples

Internal Process	Instructional Event	Action Example
Reception	Gaining attention	Informing each reactor operator candidate how to implement the PBT Qualification Guide
Expectancy	Informing learners of the objectives	Presenting the learning objectives and identifying skills, knowledge and tasks
Retrieval to working memory	Stimulating recall of prior learning	Recalling the theoretical/practical knowledge and skills of previously taught lessons
Selective perception	Presenting the stimulus	Presenting the working environment: the HFBR control room and equipment area
Semantic encoding	Providing learning guidance	Focusing on learning objectives related to skills, knowledge and task performance
Responding	Eliciting performance	Requiring reactor operator candidate to perform or simulate task depending on plant status
Reinforcement	Providing feedback	Requiring a written comprehensive exam after learning the required skills and knowledge prior to performing task
Retrieval and reinforcement	Assessing performance	Requiring task performance; evaluating each task performed.

Internal Process	Instructional Event	Action Example
Retrieval and generalization	Enhancing retention and transfer	Requiring a written comprehensive exam on skills, knowledge, and tasks performed. Requiring oral examination to perform or simulate tasks.

Assessment System Specification

The shift supervisor evaluates each trainee based on the learning objectives which identify the skills and knowledge. Upon successfully completing all system objectives, the Training Group prepares a comprehensive written exam. The standard passing grade of 80% is required. If the trainee passes, the individual proceeds to task performance; if the trainee fails to meet the standard, counseling and remedial training are provided.

When OJT is completed, the trainee takes a second comprehensive written exam which covers selected skills, knowledge, and tasks required. The next step is to take an oral walk-through exam to perform or simulate tasks associated with plant operations. It is important to note that the shift supervisor prepares the trainee. Supervisors and managers who are not involved in preparing the trainee prepare the trainees' written and oral exams.

Evaluation System Specification

Formative and summative evaluation methods were used for this project. Evaluation is a continuous process used to improve operator performance, as well as trainee learning material. Improvements or changes to the Guide may occur as a result of procedural changes, operating philosophy, or plant modifications. Such changes will require a review of cognitive knowledge and motor skills required to perform tasks.

Formative

As each PBT Qualification Guide/Checklist was developed, it was critiqued by plant management, shift supervisors, and reactor operators and minor revisions resulted. The Guide was tested in a small group evaluation trial and, as a result, the evaluator's signature format was revised. The Qualification Guide was then presented to the HFBR Curriculum Review Committee for final evaluation prior to implementation. The Operation Group committee representative identified which tickler cards within the Guide were required to be performed for the reactor operator position.

Summative

Kirkpatrick's (1987) four levels of evaluation were conducted for the summative evaluation: reaction, learning, behavior, and results.

1. Reaction to the implementation of the PBT Qualification Guide/Checklist was evaluated during group presentations, interviews, by written critique, and with questionnaires.
2. Learning was gauged by shift supervisor evaluation as well as written examinations.
3. Behavior was monitored during implementation, group presentation, and interviews.
4. The outcome did indeed achieve the desired results. First, to increase and standardize the skills and knowledge level. Second, to standardize the method to evaluate trainee performance.

Learning Transfer System Specifications

The PBT Qualification Guide/Checklist will be incorporated in Appendix D of the HFBR Training Plan. The Training Plan is a document which sets forth the policy of the BNL Reactor Division with regard to the selection, training, and retraining of the RD personnel associated with the HFBR. The HFBR Training Curriculum Review Committee continues to evaluate the implementation of the PBT Qualification Guide/Checklist to ensure the proper reaction, learning, behavior, and results are achieved. Each trainee is administered a Qualification Guide and assigned a shift supervisor to ensure the required skills and knowledge for task performance are achieved.

Review and Selection of Existing Materials

The original Qualification Guide was reviewed for its content to ensure that the analysis performed did not eliminate any required skills, knowledge, or tasks in the new PBT Qualification Guide/Checklist.

Summary

The job and task analysis identified the skills, knowledge, and tasks for the reactor operator position. The skills and knowledge statements were grouped and supported by performance-based objectives. The objectives were properly sequenced to ensure sequential learning. The tickler cards required to be performed for the reactor operator position were selected by the group leader. Reference material to support training was identified as well as the preferred method to evaluate each task performed.

CHAPTER 4

DEVELOPMENT

Introduction

The analysis and design chapters which preceded identified the training needs and outlined the instructional requirements to meet these needs. During the development phase a methodology for implementing the PBT Qualification Guide/Checklist was devised. This was followed by the development of a segment of the Guide for a specific plant system. The methodology for implementation and the plant system segment were both critiqued by plant personnel. Based on this critique modifications were made to improve both the implementation and the specific system segment. Once improvements were incorporated, the material developed was presented to the HFBR Curriculum Review Committee for approval.

Learning Activity Development Scheme

Firstly, a user-friendly implementation manual to support the PBT Qualification Guide/Checklist was incorporated. This included the following topics:

1. Methodology for completion of Qualification Guide
2. Performance guidance
3. Procedural and tickler card performance
4. Instruction for implementation
5. Evaluation sign-off requirements
6. Instructions for document transmittal
7. Additional task performance list

This portion of the manual was distributed to plant management and supervisors for review.

Secondly, a PBT Qualification Guide/Checklist segment was developed for a specific system. The Shutdown Cooling Water System (SCWS) was chosen for its simplicity. Once the SCWS segment was developed, it, too, was distributed to plant management, supervisors, shift supervisors, and certified reactor operators for review. The certified shift supervisors and reactor operators were used to verify its technical content. Plant management and supervisors have the technical expertise to review any Guide segment; however, the shift supervisors and certified reactor operators were requested to review the document for the following reasons:

1. They already know the skills and knowledge required for operating the SCWS.
2. Since they operate the system on a daily basis, if any items were missed they would be easily picked up.
3. They were additional SME's used to validate the task analysis.
4. They were additional personnel to verify that the performance-based objectives were understood.
5. A sense of ownership of the new document was instilled.

Once the critiques of the implementation manual and SCWS segment were reviewed, modifications were incorporated. This input improved the methodology for implementation and technical accuracy of the SCWS segment. It was then presented to the HFBR Curriculum Review Committee for approval.

Learning Activity Development

The following material was accumulated to support the development phase:

1. Existing Qualification Guide/Checklist which is part of the HFBR Training Plan
2. Plant Description Manual
3. Plant Operating Procedures
4. Technical Specifications
5. Job and task analysis performed in 1983
6. Tickler cards
7. Administrative Procedures Manual

The user friendly implementation portion of the Guide used to assist the trainee and trainer was developed to be incorporated in the new PBT Qualification Guide/Checklist.

The skills and knowledge were identified for each system segment of the manual that was based on the task analysis. This phase included developing the performance-based objectives and identifying how each skill and knowledge was to be evaluated.

The fourth phase involved developing tasks required for performance that were identified by the job analysis and yet are supported by the skills and knowledge previously identified. This phase also identified how each task was to be evaluated.

Learning Activity Review

With the exception of two systems the designer, who is also a certified shift supervisor, developed the PBT Qualification Guide/Checklist. As each system and procedural section was developed, it was distributed to management, supervision, and operations personnel for review. Several SME's were utilized to verify that the content was technically accurate, grammatically correct, properly formatted, and that the learning activities were properly identified.

Materials for Evaluation Produced

The PBT Qualification Guide/Checklist has five functions:

1. Provides the trainer and trainee an implementation tool.
2. Provides evaluation signature block to indicate proper performance of skills, knowledge and tasks completed.
3. Provides a means to review and update tasks that have been added or deleted to maintain the document current.
4. Provides a method to monitor trainee progress.
5. Provides valid documentation to indicate completion of OJT.

A portion of the PBT Qualification Guide/Checklist was used in a small group trial to evaluate its effectiveness. Five trainees and one shift supervisor participated in the trial which resulted in modifications being made to the document. The PBT Qualification Guide/Checklist was also presented during the shift supervisor/reactor operator quarterly requalification training. This presentation also resulted in additional revisions.

The evaluation of the Guide is an on-going process which will continue as long as the HFBR continues to operate for the scientific community.

Summary

The PBT Qualification Guide/Checklist instructs the trainee and trainer on how to implement the document. It also identifies the skills, knowledge, and tasks required for certification. The guide for implementation and a specific plant system checkout were developed. These were then critiqued by plant personnel. Prior to full-scale development, training material was collected to support the process. As each segment of the Guide was developed, it was evaluated by SME's for technical accuracy as well as verifying that the learning activities were properly identified. A small group trial and presentation of this document to the shift supervisor/reactor operator resulted in incorporating revisions.

CHAPTER 5

IMPLEMENTATION

Introduction

All the material in the PBT Qualification Guide/Checklist was designed to be implemented and used for training in the OJT environment as well as in the classroom. Classroom training is provided if three or more trainees join the Operations Group on or about the same time or if shift supervision is understaffed or overburdened with existing trainees. Classroom training is supported by OJT tours to meet the intent of the PBT Qualification Guide/Checklist. Each trainee is given his own Guide with supporting material for implementation.

Materials for Implementation Reproduced

After the revisions were made to the PBT Qualification Guide/Checklist copies were distributed to the reactor operator trainees. Additionally, one master copy of the Guide was assigned to the HFBR control room for shift supervisor use. This copy has Hand Processed Changes (HPCs) incorporated in it. An HPC is a hand-written revision made as a result of a necessary change in skill, knowledge, or task requirements. This process keeps the trainee current with newly implemented program requirements. On a semi-annual or annual basis, depending on how many HPCs exist, the document is permanently updated to incorporate the HPCs.

The following supportive material is distributed to each trainee:

1. HFBR Training Plan
2. Plant Description Manual
3. Plant Operating Procedures
4. Technical Specifications

Instructional Delivery

Classroom Setting

During the small group trial the five trainees met each morning with the shift supervisor. A schedule was given which identified the systems that were to be covered. To maximize classroom participation tables were arranged in a "U" shape. The trainer and trainees were instructed on how to implement the PBT Qualification Guide/Checklist.

Presentation Method

During the classroom presentation the objectives for each system listed in the Plant Description Manual were identified by the shift supervisor. Next the PBT Qualification Guide/Checklist objectives, skills, and knowledge were introduced. Therefore, prior to instruction the trainee was aware of cognitive knowledge and motor skill requirements.

The shift supervisor used a white board and overhead transparencies to assist lecture presentation. Once the classroom presentation was completed for each system, a tour of the HFBR facility was given for that specific system. Classroom presentation was reinforced by the tour within the HFBR since that environment is conducive to learning the skills and knowledge required for task performance. Once all the fundamental systems were completed in this manner, the trainee was given additional time in the HFBR to walk through all the systems taught. When the trainee was ready to be evaluated, the shift supervisor used the appropriate methods in the Guide; i.e., discussion, observation, simulation or performance, to evaluate each trainee. If the trainee completed the test item successfully, the shift supervisor signed in the space provided. If a test item was not successfully completed, no sign offs were permitted. The trainee who does not successfully complete the evaluation must perform remedial training. Once the trainee is ready, the evaluation process is repeated.

OJT Setting

The OJT setting is not as formal as the classroom. The trainee is under the wing of the assigned shift supervisor. There is more flexibility provided depending on the agreements worked out between the trainee and shift supervisor. All training occurs in the HFBR environment.

Presentation Method

The trainee must be self-motivated and review the objectives in the Plant Description Manual as well as review the objectives, skills, and knowledge associated with the PBT Qualification Guide/Checklist. When the trainee has questions, the certified reactor operators and shift supervisors are available for assistance. A white board for instructional use and performance testing is available in the shift supervisor's office. Once the trainee is ready to be evaluated, the evaluation process is no different than the one mentioned above.

Data Collection

Implementation of the PBT Qualification Guide/Checklist training and learning process was effectively evaluated in three settings: the first involved the shift supervisors and certified reactor operators; the second involved supervision and management; the third involved the shift supervisor, certified operator and the trainees. The critique involved the following questions:

1. Was the instruction given to implement the Guide useful?
2. What improvements to the instruction guide should be considered?
3. Were the skills and knowledge statements appropriately identified?

4. What improvements to the list of skills and knowledge statements should be considered?
5. Were the performance-based objectives definitive and properly sequenced?
6. What improvements to the objectives and their sequence should be considered?
7. Were the tasks properly identified?
8. What improvements to the task list should be considered?
9. Did the Guide effectively identify the proper method to evaluate the skill, knowledge, or task performed?
10. What improvements should be considered in identifying or re-establishing the proper evaluation method for each skill, knowledge, or task required?

The responses to the above data were used to revise portions of the PBT Guide and to accumulate feedback which will be incorporated into the next revision.

Summary

The PBT Qualification Guide/Checklist was effectively implemented during the small group trial and during the pilot test phase. The document is currently being used by all new trainees presently on shift. The Operations Group Leader officially approved usage of this document on December 13, 1990, as shown in Appendix E, under an extended pilot test program. The participants unanimously felt that identifying the skills, knowledge, and tasks required increased the learning in dealing with normal, abnormal, and emergency plant conditions. The participants also felt that by identifying the evaluation method for testing the trainee and trainers were better prepared during the evaluation process.

CHAPTER 6

EVALUATION

Introduction

Evaluation is the final phase of the Instructional System Design model to determine whether the objectives or instructional goals have, in fact, produced the desired product. Determining if the PBT Qualification Guide/Checklist covered all the skills, knowledge, and tasks required for the reactor operator position, and determining if the method was properly selected to evaluate trainee performance takes place by monitoring such key factors as trainee performance, plant modifications, plant procedure changes, and plant availability. Evaluation feedback helps maintain and improve the training program.

There were several mechanisms used to evaluate both the training process and the resultant product. The formative evaluation which consisted of one-on-one trials, a small group trial, and pilot test had shown a need to revise the PBT Qualification Guide/Checklist. Changes were incorporated after each evaluation process.

Kirkpatrick's (1987) four levels of evaluation were conducted for the summative evaluation. This included reaction to the training, learning that took place, change in trainee behavior, and the end result achieved. The PBT Qualification/Guide/Checklist is in constant use. There is a need to keep this document current to ensure that the trainees and trainers are provided with updated information.

Formative Evaluation

Designing and conducting formative evaluations is an invaluable process in the preparation of instructional materials. Formative evaluation is the collection of data and information during the development of instruction which can be used to improve the effectiveness of the instruction Dick and Carey (1985). Many times instructional products are distributed which have not been evaluated by the learners prior to formal implementation. Studies indicate that by first trying out the materials with a learner, data is collected to revise the material which results in increasing the effectiveness of that material.

All three phases of formative evaluation were used to produce the PBT Qualification Guide/Checklist. During the first phase (one-on-one) the designer worked with a manager, a shift supervisor, and a certified operator (since there were no new trainees available at that time) to collect data and revise the material. During the small group trial phase the designer worked with one shift supervisor and five trainees to collect data and revise the material. During the pilot test trial phase the designer worked with several shift supervisors, certified operators, and trainees to collect data to revise the material. Each phase of the formative evaluation process definitely impacted the effectiveness of the material presented.

One-on-One Evaluation Trial

There were no new trainees active within the program to perform a one-on-one evaluation trial; however, a manager, a shift supervisor, and a certified reactor operator were selected to give evaluations. These individuals were asked to evaluate the following:

1. Format
2. Implementation guide
3. Skills and knowledge selected for training
4. Performance-based objectives
5. Sequencing of objectives
6. Tasks selected for training
7. Evaluation methods selected

As a result of this trial the following contributions were made:

1. The implementation guide placed more emphasis on the proper communication between the trainer and trainee during task performance.
2. Additional skills and knowledge were identified for training.
3. More emphasis was placed on identifying the location of components through objective wording; i.e., locate and discuss.
4. Evaluation of several emergency procedures initially selected for performance was changed to simulation and discussion.

Small Group Evaluation Trial

After completion of the above revisions, the document was evaluated by a segment of the target population which consisted of one shift supervisor and five reactor operator trainees. The shift supervisor's instruction to trainees was initially held in the classroom and then in the HFBR environment. This trial was cost effective due to the following considerations:

1. Five trainees were taken off shift to free shift supervisors to perform other duties.
2. None of the trainees had security clearance; therefore, being taken off shift reduced the escort requirements.
3. The shift supervisor was the trainer as well as the escort.
4. All the trainees were in synch which minimized instructor preparation time.

As a result of this trial the following contributions were made:

1. The evaluation signatures were reduced from signing off every skill, knowledge, and task requirement to groups of skills, knowledge, and tasks.
2. Additional skills, knowledge, and tasks were added due to ongoing modifications.
3. Procedure for document transmittal was upgraded to include completed segments of the Guide be transmitted to the Training Manager and a copy retained by the trainee.

Pilot Test Trial

Revisions were made based on the small group trial evaluation process. The material is now being tried out by all new trainees and shift supervisors in the pilot test. Copies of the PBT Qualification Guide/Checklist were distributed to all new trainees.

As a result of this trial the following contributions have been made to date:

1. Identified that the Plant Description Manual needed to be upgraded to include additional skills and knowledge required by the Guide.
2. Deleted specific skills, knowledge, and tasks that were not officially addressed in the Operating Procedures Manual.
3. Developed a "Request for Clarification Form" for requesting training assistance to help clarify a specific skill, knowledge, or task within the Guide.

Summative Evaluation

The formative evaluation collected data and information to improve the PBT Qualification Guide/Checklist. In order to determine if the PBT Qualification Guide/Checklist was indeed effective, a summative evaluation was conducted. Dick and Carey (1985) define summative evaluation on the design, collection, and interpretation of data and information for a given set of instruction for the purpose of determining the value or worth of that instruction. The four levels of summative evaluation described by Kirkpatrick (1987) were used for this instructional unit. The four levels are reaction, learning, behavior, and results. Questions asked in Appendix G were used to collect data for the summative evaluation.

Reaction

Management, shift supervisors, certified operators, and trainees were receptive during the analysis, design, development, implementation, and evaluation phases of this project. Almost all the personnel felt that the end product delivered was indeed an improvement over the previous document. Initial problems in implementing the document were resolved by giving a formal presentation during requalification training for four consecutive weeks.

Some specific comments made by the above evaluators included:

1. The format used to identify the proper evaluation method (i.e., PSOD) was confusing.
2. That a minimum number of task evolutions should be required prior to signing off any task as being completed.
3. Some of the skills, knowledge, and tasks should be deleted.
4. Improvements needed to be made to make the formatting consistent.
5. Certain skills and knowledge statements should be deleted specifically since they were not covered by the Operating Procedures Manual.

Both the shift supervisor and the trainees appreciated the fact that the method of evaluation was identified up front.

Learning

The goal of identifying all the skills, knowledge, and tasks required for the reactor operator's position was to standardize learning content. This ensures that each time a trainee is certified a consistent degree of skill, knowledge, and ability has been achieved. Several trainees who participated in the small group trial thought they learned more because the skills and knowledge required were identified. This made the learning process more effective and minimized time spent on items not required. The shift supervisor agreed with the trainees noting, in particular, that everything was identified up front and that the skills, knowledge, tasks and evaluation method used effectively stream-lined the learning process.

Table 6 identifies the grades received by the reactor operators on the system fundamentals exam. The evaluation instrument used to evaluate the trainees is the HFBR Fundamental Program System Training Examination (1990) prepared by Brookhaven National Laboratory Reactor Division personnel which is incorporated in Appendix F.

Table 6
Reactor Operator System Fundamentals Test Results

Student	Grade
1	92.3%
2	88.3%
3	85.3%
4	*
5	*

* Student did not complete the prerequisite required at the time the examination was given.

Behavior

The purpose of the PBT Qualification Guide/Checklist was to improve and standardize the cognitive knowledge and motor skills required for task performance and to standardize the method used to evaluate each skill, knowledge, and task performed. Prior to this document, it was left up to the judgment of the assigned shift supervisor trainer to determine the depth of knowledge to be tested. It was the shift supervisor who also determined what evaluation method was to be used.

There was definitely a change in behavior on the part of the shift supervisor trainer. The general consensus was that the new document was indeed better suited for on-the-job training, but that it would take some time to get used to. Some of the problems encountered included that even though the trainers thought the process was well structured, they still had the need to ask their favorite "nice-to-know" questions. Some felt they lost their freedom to not use what they believed was the "perfect" methodical approach.

The most significant change in behavior was on the part of the trainee who experienced far less frustration since he knew what was expected during the evaluation process.

Results/Impact

It is quite difficult to measure the results and impact of implementing the PBT Qualification Guide/Checklist at this time. Some of the performance indicators that could measure impact are as follows:

1. Shorter time for reactor operators to achieve qualification since training is more focused.
2. Less time for shift supervisors to evaluate trainees since training is more structured.
3. Fewer "mistakes;" e.g., fewer unplanned reactor trips because of better preparation of the operators.
4. Reduced time in troubleshooting/correcting trips or operating problems.
5. Increase in plant efficiency.
6. Fewer reportable occurrence notices to the Department of Energy due to fewer errors.

As trainees progress through the learning process and achieve reactor operator certification, their performance, over the long term, should give positive results. One would anticipate a moderate to significant impact on improving operator performance. The new trainees will be exposed to a higher level and more comprehensive list of skills and knowledge than their predecessors. The additional cognitive knowledge attained by the trainees should have a ripple effect and improve the level of knowledge of the current reactor operators and shift supervisors.

Learning Transfer

The PBT Qualification Guide/Checklist was reviewed and approved by the HFBR Training Curriculum Review Committee. This committee sets HFBR policy and is composed of management personnel. The plant manager and operations group leader sit on the committee and influence policy regarding initial and continuing training for shift supervisors, reactor operators, and trainees. The plant manager, group leader, and assistant group leader, who are not involved in the training process, test each trainee. During the evaluation process an oral comprehensive walk-through examination is given to determine if learning transfer has taken place. The examiners are kept current by attending requalification training on a quarterly basis. In addition, they monitor plant performance on a daily basis and manage day-to-day operations at the facility.

Summary

The formative evaluation consisted of three phases. The first phase was the one-on-one evaluation trial which led to suggestions that were incorporated. The second phase was the small group evaluation trial which actually interrelated with the learning process. This led to additional changes that were also incorporated in the upgraded document.. The third phase is the pilot test trial. This process is also identifying additional work that must be done prior to finalizing the document. Once the trainees complete the PBT Qualification Guide/Checklist we expect to see an increased level in cognitive knowledge directly relating to an increase in each individual's productivity as well as an increase in plant efficiency.

CHAPTER 7

SUMMARY AND RECOMMENDATIONS

Introduction

The PBT Qualification Guide/Checklist was upgraded to standardize the knowledge level of the reactor operator trainee as well as to standardize the process used to evaluate performance. As a result of these changes an improvement in the trainee's attitude and behavior has been recognized. This chapter will give an overview of the entire project including methods, procedures, conclusions, and recommendations.

Methods and Procedures Used

This PBT Qualification Guide/Checklist was designed based on the Instructional System Design model (ISD). The five phases of ISD were used to develop this project. Each of the five phases, analysis, design, development, implementation, and evaluation are summarized below. The training took place in the classroom and in the HFBR environment.

Analysis

The PBT Qualification Guide/Checklist was upgraded to comply in part with DOE Order 5480.18, "Accreditation Orders." The needs analysis identified that the skills, knowledge, and tasks required should be standardized. In addition, the method used to evaluate each trainee was standardized. A job and task analysis was performed to identify all the skills, knowledge, and tasks required for the reactor operator position.

Design

The design phase of the project was driven by the analysis phase. During the design phase the following material was developed:

1. Implementation guide
2. Evaluation guide
3. Generic job performance measures
4. Grouping of skills and knowledge
5. Grouping of task
6. Performance-based objectives

Development

Material was developed for each unit of instruction to be evaluated. The skills and knowledge checklist was developed first followed by the tasks required for performance. Additional material developed included the following:

1. Methodology for completion of the PBT Qualification Guide

2. Performance guidance
3. Procedural and tickler card guidance
4. Instruction for implementation
5. Evaluation sign-off requirements
6. Instructions for document transmittal
7. Additional task performance list

The instructions listed above were distributed for plant management and supervisor review.

Implementation

The PBT Qualification Guide/Checklist was effectively implemented during the small group evaluation trial which consisted of five trainees and one shift supervisor. Classroom instruction was given prior to in-plant tours to identify specific system components. The last phase of implementation is during the pilot test phase which is effectively going on at the present time.

Evaluation

A formative evaluation was performed using three different techniques. The first was a one-on-one trial which was implemented prior to full-scale development. The second was a small group trial prior to completion of the document. The third and final phase is a pilot test trial. Each phase of the formative evaluation process identified adjustments required to improve the document. After each phase of evaluation the feedback was used to upgrade the document before going on to the next phase.

The four levels of summative evaluation described by Kirkpatrick (1987) were used to evaluate the document. The reaction had both positive and negative feedback, but the overall results were favorable. Most individuals felt that the end product was an improvement over the previous document. There was some confusion during the initial implementation phase; some felt that the format of the Guide could be improved and another felt that there should be a minimum amount of time within which a task should be performed prior to formal evaluation. The learning process was standardized. This ensured that each trainee was exposed to the same skills, knowledge, and task required for the position. There was a change in behavior on the part of the trainee and trainer. Each exhibited less frustration due to the fact each knew up front what was expected.

Conclusion

Standardizing the skills, knowledge, and tasks a reactor operator trainee must learn as well as standardizing how each is evaluated was the goal of this project. The degree of confidence has increased knowing that after 12 to 14 months of training the level of skill and knowledge desired is achieved. What is most important is that the desired level is achieved regardless of which shift supervisor is assigned to the trainee. There is less frustration exhibited both at the part of the trainee and trainer. This is a result of knowing up front what is required during the learning and evaluation process. The Guide has also elevated the cognitive knowledge level of the current group of reactor operators and shift supervisors on HFBR operations.

As a result of this project the new Guide is a more user-friendly document since it indexes all skills, knowledge, and tasks; identifies tickler cards required for certification; provides instruction for implementation; identifies reference material for each system segment; and identifies additional task performance not included in the Guide.

Recommendations

Performance-based training cannot be totally encompassing unless a real time plant specific simulator is built to model HFBR normal, abnormal, and emergency operations. The Guide does address normal, abnormal and emergency operations but to simulate (walk-through and describe performance versus actual performance) is the best we could do at this time for most emergency conditions. A simulator can be used to focus on the cognitive knowledge and motor skills to integrate plant operations. Man-machine systems exist to do work. They are worth developing only if the work they do cannot be done easily or correctly by men alone. (Edwards 1966)

Additionally, a real time plant specific simulator can be used to monitor team work and diagnostic skills of individuals. There is a relationship in which people generate and use work procedures to make possible their interactions with machines, machine procedures, and other people in the pursuit of system objectives. (Boguslow 1966)

During the formative evaluation process, the pilot test trial phase identified a need to upgrade the Plant Description Manual (PDM). Secondly, lesson plans have to be developed to support each PDM section to include the following:

1. Task selected for Training
2. Terminal objectives
3. Enabling objectives
4. Reference material
5. Improve graphics/visual aides
6. Update text to include what is required in the Guide.

Concluding Statement

Human intellectual ability is limited. Operating sophisticated machinery of today and that of tomorrow will require an integrated network of people, machine, and computer. The art of designing such integrated systems, and its success, is the only barrier that must be overcome to continue to discover what yet remains unknown.

APPENDIX A

REACTOR OPERATOR PBT QUALIFICATION GUIDE/CHECKLIST

INCLUDING EVALUATION CRITERIA

High Flux Beam Reactor
REACTOR OPERATOR QUALIFICATION GUIDE CHECKLIST

Trainee: ______________________ Life No: ____________

Date Issued: ______________________

Projected
Completion Date: ______________________

Date Completed: ______________________

Qual Guide Checklist
Completion Review: ______________________/__________
Trainee Concurrence Date

______________________/__________
Training Manager Date

Approved by: ______________________/__________
Operations Group Leader Date

______________________/__________
Training Manager Date

REACTOR OPERATOR QUALIFICATION GUIDE CHECKLIST

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101	F5.11	"Chemical & Scintillation Supplies Inventory"		
102	F5.11	"Beckman Efficiency Check"	X	
103	A7.12	"Charging of Walkie-Talkie Batteries"		
104	M	"Yale Work Saver #1"	X	
105	M	"Fork Truck"	X	
106	M	"Yale Work Saver #2"		
107	F5.10	"Primary System Acidification"	X	
108	H7.8	"Breathing Air Manifold System"		
109	E4.3	"Pre & Post Reactor Shutdown Checklist"		
111	H7.3	"Engine Generator Test for Startup Checklist"	X	
113	F5.2	"Cooling Water Pump Rotation"	X	
115	G6.2	"Heat Balance Comparison"		X
116	G6.6	"Safety Circuit Tests"	X	X
117	H7.5	"Bldg. Confinement Leak Rate"	X	X
118	M	"Welding Supplies Inventory"		
119	M	"Tool Inventory"		
120	M	"Gasket & Packing Inventory"		
121	N	"Emergency Cabinet Inventory"	X	
123	H7.7	"Sling & Rigging Equipment Insp."		

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125	J9.3	"Fuel Element Inventory"		
126	H7.1	"Emergency Gas Supplies Bottle"	X	
127	B1.2	"Log Sheet & Logbook Check"		X
129	F5.11	"Primary System Conductivity Cell Check"		
130	I8.1	"HFBR Top/Table of Shutter Shadowing Effects"		
131	F5.11	"Poison Water Chemical Content"	X	
132	J9.3	"Fuel Handling Lifting Head Air Hose Replacement"	X	
135	H7.2	"Battery Bank No. 1 Charge"	X	
136	H7.2	"Battery Bank No. 2 Charge"		
138	H7.3	"Kilowatt-Hour Readings"	X	
139A-G,I	L	"Self-Contained Breathing Apparatus TC Check"		
139H	L	"Self-Contained Breathing Apparatus TC Check"		
141	F5.2	"SD Cooler Secondary Supply Valve WR-3 Actuator Stop Adjustment"	X	
142	F5.2	"SD Cooler Secondary Return Valve, WR-3 Actuator Stop Adjustment"	X	
143	F5.2	"Pri. Cooler Secondary Valves, WR-1 & 2, Actuator Stop Adjustment"	X	
144	H7.5	"Air Lock Doors, Emergency Bottle Check"	X	
145	M	"Yale Work Saver #3"		

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147	H7.5	"Bldg. Ventilation Operating Data"		
151	M	"Swagelok Fittings Inventory"		
152	M	"Operations Machine Tool Maint."		
153	F5.1	"Test of HC-102A & B Valve Operations"	X	
154	B1.2	"Record of Operating Conditions"		X
155	N	"HFBR Operations Group - Safe Combination Changes"		
156	H7.3	"Engine Generator Operational Check"	X	
158	G6.5	"Main Control Rod Scram Curves"		
160	G6.5	"HFBR Main Control Rod Shutdown Margin Test"		X
161	F5.8	"CO_2 Vaporizer Purge"	X	
162	L	"Monthly Check of Self-Contained Breathing Equipment"	X	
163	F5.12	"Test & Inspection of Poison Water Dump Valves"	X	
164	G6.5	"Control Rod Travel Time"		X
165	H7.3	"Emergency Generator System Components Tests"		X
166	G6.6	"Test of PPS Power Supplies for Shorts & Grounds"		X
167	N	"Review HFBR Emergency Plan"		
168	M	"Periscope Purge, Pressure, Inventory"		

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170	F5.2	"Operation of CT Return Pump GA-303A & WR-14 Valve"	X	
172	H7.7	"Rigging Equipment Inspection"		
173	H7.7	"Sling Inspection"		
175	G6.5	"Main Control Rod Scram Times"		X
176	H7.2	"Individual Cell Voltage Readings 250V Battery System"	X	
177	H7.2	"Specific Gravity of 250V Battery System Cells"	X	
178	F5.7	"Primary Safety Valve Test"		X
179	F5.1	"Pump Seal Vent System Collection Tank Draining"	X	
180	J9.3	"Fuel Handling Tools Inspections"		X
181	N	"HFBR Emergency Plan "On Call" List"		X
183	F5.2	"Secondary Water Isolation Equipment Tests"		
184	F5.11	"Water Chemistry - Tech. Spec. Surveillance Requirements"	X	X
185	M	"Black Iron Fittings"		
186	F5.2	"Test of Gravity Feed Flow to SD Heat Exchanger"	X	
187	O	"Radiation & Contamination Survey-HFBR Bypass Filter Facility"		
188	H7.8	"Breathing Air Compressor Operation Check"	X	

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190	H7.2	"Check of Emergency Lights"	X	
191	F5.1	"Pony Motor Batteries Cell Voltage & Specific Gravity Readings"	X	
193	F5.1	"Pony Motor Battery Equalizing Charge "A" & "B"	X	
194	H7.2	"Test of Emergency Power Supplies"	X	
195	M	"Gas Fork Lift Battery Charge"	X	
196	H7.10	"Test of Break Tank Overflow Protection"	X	
197	H7.6	"Inspection of BG-201 Valve Diaphragms"		
198	M	"Yale Work Saver #4"		
199	G6.15	"NIAS & BVRV Tests"	X	
201	F5.12	"Poison Water Tank Safety Valve Test"		
202	F5.3	"Semi-Annual Test - Pony Motor Battery Supplies"		X
203	H7.5	"Air Handling Unit - Filter Replacement"		
204	J9.3	"Calibration of Fuel Element Measurement Instruments"		
205	H7.2	"Semi-Annual Test - 250V DC Batteries No. 1 & No. 2"		X
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208	F5.3	"Shutdown Pump Switchgear Tests"	X	

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211	F5.2	"Well Water Cooling Line Flow Test"	X	
213	B1.2	"Manual & Procedures Inventory"		
214	F5.11	"Iodine Sampling Program"		X
215	G6.11	"Rolling Shield Interlocks"	X	
216	B1.2	"HFBR OPM Review"		
217	G6.14	"Calibration Check of NMC Gamma Monitors"		
218	F5.7	"Eductor Pump Protection Trip Circuit Tests"	X	
220	B1.2	"Control Room Procedure & Checklist Inspection"		
221	F5.11	"Primary System Iodine Sample"	X	
222	B1.2	"Laboratory Safety Policy Manual Review"		
223	B1.2	"Posted Procedure Check"	X	
224	B1.2	"HFBR Lock-Out/Tag-Out Verification"		X
225	B1.2	"HFBR Tech. Spec. Review"		
228	H7.4	"D Waste Pump Sump Tritium Check"	X	
809	O	"Inspection of SS Storage Areas"		

TC#	QUAL GUIDE SECTION	TICKLER CARD TITLE	REQUIRED	
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230	N	"Building Evacuation Drills"		
231	N	"HFBR Building Access List"		
232	O	"Inspection of Decontamination Showers"	X	
233	O	"Operations Beta-Gamma Counter Efficiency Check"	X	
234	N	"Special Access List Update"		
235	B1.2	"Overtime List Update"		
236	F5.8	"CO_2 Cavity Tritium Sample"	X	
237	M	"Calibration of Reactor Division Torque Wrenches"		
239	F5.11	"Beckman Standard Efficiency Check"	X	
240	B1.2	"Operations Group Procedures Review"		
241	I8.1	"Test of Security - Controlled Shutter Closing & Exp. Crane Inhibit Switches"		X
242	I8.2	"V-15 Thimble Check"		
243	I8.1	"Reactor Vessel Beam Tube Inspection"		
244	G6.16	"D_2O Leak Cabinet Check"	X	
245	F5.8	"Portable Oxygen Analyzer Sensors"	X	
246	N	"Operating Schedule Security Delays"		

TC#	QUAL GUIDE SECTION	TICKLER CARD TITLE	REQUIRED RO	SS
247	N	"Alarmed Key Box Checks"	X	
248	A7.12	"Technical Support Staff Communications Check"		
249	B1.2	"Non-Reactor Personnel Work Permit Review"		X
250-260	B1.2	"HFBR Inspection Shift Supervisors"		
262	B1.2	"HFBR Logbook Review"		
263A-F	F5.2 F5.1	"Manual Operation of Automatic Valves"		
264	F5.9	"Heavy Water Changeover"		
265	H7.1	"Operation of Backup Air Compressor GB-301C"	X	
267	M	"Spare Parts Inventory"		
268	F5.2	"Winterizing Cooling Towers and Outside Areas"		
269	F5.7	"Lab Chromatograph"	X	
276	A7.11	"Sprinkler Piping - Internal Inspection"		
277	F5.7	"Steam Vent Valve Breakaway Torque/Air Pressure Measurements"	X	
279	K10.2	"Removal of Uncut Fuel Rack Heavy Cover"	X	
280	H7.4	"Liquid Waste Line Integrity Check"		
281	I8.2	"Replace V-11 Hydraulic Pump"		
282	I8.1	"Test of Spectrometer Beam Shutter Lockout Switches"		

TC#	QUAL GUIDE SECTION	TICKLER CARD TITLE	REQUIRED RO	REQUIRED SS
283	F5.7	"P300 Valve Assembly Maintenance"		
285	O	"Annual Review of RD Radiation Work Permits"		
286	M	"Fork Lift Meter Readings"		
287	B1.2	"Material Safety Data Sheet Review"		

INTRODUCTION

The Reactor Operator Qualification Guide is used for all HFBR Reactor Operator and Reactor Supervisor trainees and is to be implemented according to the guidelines in Section 3.0 of the HFBR Reactor Training Plan. This guide is a tool listing all the skills, knowledge and tasks that must be completed to achieve HFBR Operator Certification. It is expected that each trainee will learn the skills and knowledge required to perform each task. The completed guide will document an Operator's ability to perform the tasks required for their job position.

Section A contains the major plant systems, equipment function, instrumentation and controls that an Operator trainee must understand. During execution of this segment the trainee should seek instruction from the Shift Supervisor, study information on the subject matter, be able to state the purpose, location, construction and principles of operations for these systems and equipment. This section should be completed first unless it is beneficial for the trainee to get involved in a specific plant evolution, tickler card test etc., and has received Shift Supervisor authorization. Once the trainee has completed this section, a thorough written examination will be given to monitor trainee performance.

Sections B & C contain the administrative rules and limits which ensure reactor and personnel safety. The trainee must be able to state these rules and limits and describe the bases for each.

Sections D through K contain procedures and tickler cards that are performed by the Operations Group. Adherence to procedures and tickler cards is required to ensure that operational evolutions are performed in a safe, efficient and consistent manner.

Sections L & M of the guide contain miscellaneous as well as day crew skills and knowledge tasks.

Sections N & O contain procedures and tickler cards that are performed by the Operations group. Adherence to procedures and tickler cards are required to ensure that security is not compromised and that the HFBR maintains proper radiological controls of its environment.

Methodology For Completion of Qualification Guide

The Operator and Supervisor trainee is responsible for the completion of the Qualification Guide.

The Operator and Supervisor trainee must aggressively pursue the completion of routine tasks outlined in the Qualification Guide.

The Operator and Supervisor trainee should inform the Shift Supervisor which task(s) are selected to be complete at the beginning of each shift. The trainee should then become familiar with any precautions, restrictions and limitations, as well as any alarms, interlocks, safety functions and control functions related to the task.

It is imperative that the Operator and Supervisor trainee realize that task performance does not simply test one's motor skills; i.e., turning a switch, operating a valve, reading a parameter, etc. Each task performed must be a well thought out process. One must understand the consequence of each step performed and its impact on both system and overall plant performance.

A professional attitude must be maintained during all training evolutions. The trainee will be expected to demonstrate good watchstanding practices. Failure to follow applicable radiological and industrial safety precautions may result in an "unsatisfactory" evaluation.

Performance Guidance

Performance of the evaluation requirement contained in the Qualification Guide does not allow the trainee to perform these tasks without supervision.

A certified Reactor Operator/Shift Supervisor shall maintain full responsibility to ensure that the trainee is supervised to prevent the system from operating outside expected parameters.

Procedural And Tickler Card Performance

The trainee shall utilize the procedure or tickler card to "walk through" and discuss the evolution (with a certified Reactor Operator or Shift Supervisor, an excellent source of operation-oriented information) prior to actual task performance. Be sure to note any Hand Processed Changes, Temporary Operating Procedure Changes, operating restrictions, cautions or notes within the procedure.

During the implementation of a procedure or a tickler card each trainee shall perform the following:

a. Read and correctly interpret all information.

b. Locate and correctly operate all equipment.

c. Perform each step in the required order it occurs.

d. Initial or sign each step, if appropriate, as it is completed.

e. Correctly interpret and evaluate any changes to system parameters caused by the evolution.

f. Interpret the final system condition upon completion of the evolution. If the condition does not match the requirements, the trainee shall correct the condition under the supervision of a certified Reactor Operator or Shift Supervisor.

g. Ensure that the system parameters stay within the required boundaries during actual performance of a task, excluding malfunctions.

h. Adhere to all safety and radiological precautions.

i. Clearly and correctly communicate information as required.

Instructions For Implementation

Each task performed must be signed and dated by a "certified evaluator." A "certified evaluator" is an individual who currently holds an HFBR Shift Supervisor Certification. The symbols P, S, O and D refer to Perform, Simulate, Observe and Discuss. The symbols indicate the evaluation tool used to monitor each skill, knowledge and task. The preferred method of evaluating a specific task is indicated in the qualification guide next to each listed task. Certain plant conditions may exist when a task can not be evaluated by the preferred method[s] established. In those cases the evaluator should write in the space provided next to the task the letter P, S, O, or D to indicate the evaluation tool used. The trainee should perform (P) all procedural and tickler card task with the exception of emergency procedures which should be simulated (S). Certain plant conditions may prohibit actual task performance, in those cases the task shall be Simulated by giving the trainee a thorough walk through and then documented. Observation shall not be the sole evaluation tool used to qualify a task unless it is indicated as the preferred method. Observation shall only be used during the initial stages of learning the skills and knowledge associated with the task or to reinforce a task that has been successfully performed. Additional tasks that are performed which are not included in the qualification guide, shall be entered on the "Additional Task Performed" list provided.

Evaluator Sign-Off Requirements

Each task, skill and knowledge requirement must be signed off individually. It is not acceptable to sign off (initial) the first evaluation and then draw a line down to the last evaluation item performed.

A Certified Reactor Operator may evaluate a trainees task Performance under the guidance of the Shift Supervisor. Once the Reactor Operator verifies that the trainee has successfully performed the task, the Reactor Operator shall notify the Shift Supervisor. The Shift Supervisor may then sign off as the evaluator.

A certified Reactor Operator may evaluate a trainees performance for the tasks in sections E through O.

If a procedural or tickler card task is required to be Performed but can only be Simulated as a result of the existing plant condition, write the letter **S** in the appropriate space, then initial and date.

ex.	TASK	P	S	O	D	Evaluator / Date
	(Task Performed) Perform "Procedure for Pressurizing Storage Tank FA101"	P	_	_	_	Rcm / 12/14/90

ex.	TASK	P	S	O	D	Evaluator / Date
	(Task Simulated) Perform "Procedure for Pressurizing Storage Tank FA101"	P	S	_	_	Rcm / 12/14/90

Instructions For Document Transmittal

Upon successfully completing a qualification guide for a specific "SYSTEM FUNDAMENTALS" or a specific "SYSTEM INSTRUMENTATION AND CONTROLS" or A SPECIFIC "SYSTEM PROCEDURES" (ie. A 5.1 or A 6.17 or F 5.2, or G 6.4) a copy of the completed document shall be maintained by the trainee and the original sent to the Training and Procedures Group Leader. An updated "Additional Task Performed" list shall also be part of the document transmittal.

*	Security Clearance Required To Perform Task(s)
#	Tickler Card Required For Operator Certification
##	Tickler Card Required For Shift Supervisor Certification

Additional Task Performed

TASK	P	S	O	D	Evaluator / Date
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REFERENCES:
HFBR PDM 5.4

A 5.4 THERMAL SHIELD COOLING WATER SYSTEM FUNDAMENTALS

SKILLS & KNOWLEDGE	P	S	O	D	Evaluator / Date
Discuss the Purpose					
Heat Load Absorption	_	_	_	D	
Vessel Support	_	_	_	D	
Shielding	_	_	_	D	
Purification System	_	_	_	D	_____ / _____
Discuss Thermal Shield Construction and Identify Construction Photos					
Upper Thermal Shield	P	_	_	D	
Penetrations in Upper Thermal Shield	P	_	_	D	
Lower Thermal Shield	P	_	_	D	
Penetrations in Lower Thermal Shield	P	_	_	D	
Thermal Shield Coils	P	_	_	D	
Cooling Water Connections	P	_	_	D	
Drain/CO2 Supply Line	P	_	_	D	_____ / _____
Discuss and Draw Flow Paths During					
TSCWS Normal Operation	P	_	_	D	
Purification System Normal Operation	P	_	_	D	
Purification System Operation with TSCWS Pumps Shutdown	P	_	_	D	
System Makeup	P	_	_	D	
Oxygen Sample Flow	P	_	_	D	_____ / _____

Draw the Thermal Shield as Illustrated in Figure 3-2	P				/
Discuss Equipment Function					
Pumps				D	
Motors				D	
Pump Seals				D	
Check Valves				D	
Suction and Discharge Valves				D	
Corrosion Test Loop				D	
Heat Exchanger				D	
Thermal Shield Coils				D	
Lower Thermal Shield				D	
Upper Thermal Shield				D	
Expansion Tank				D	
Pressure Vacuum Relief Valve				D	
Expansion Tank Vent				D	
Expansion Tank Circulating Pump				D	
Cavity Drain				D	
System Drains				D	/
Purification Subsystem					
Booster Pump				D	
Inlet Filter				D	
LiOH Mixed Resin Beds No.'s 1,2, and 3				D	
Outlet Filter				D	
Isolation, Vent and Drain Valves				D	/
Oxygen Sample Subsystem				D	
Filters				D	
Heating Coils				D	
Solenoid Valve				D	
Flow Control Valve				D	
Oxygen Analyzer				D	/

Discuss Equipment Power Supplies

TSCW Pumps _ _ _ D
TSCW Purification Booster Pump _ _ _ D
Expansion Tank Circulating Pump _ _ _ D ________/____

Discuss System Makeup and Chemistry Control

Source of Makeup _ _ _ D
pH Control _ _ _ D
Oxygen Control _ _ _ D
Sparging _ _ _ D
Nitrogen Addition _ _ _ D
Conductivity _ _ _ D
LiOH Resin _ _ _ D
Hydroxide Resin _ _ _ D
HOH/LiOH Resin Combination _ _ _ D
Lithuim Hydroxide Addition _ _ _ D
Inlet Filters _ _ _ D
Outlet Filters _ _ _ D
Grab Samples _ _ _ D ________/____

Discuss System Parameters and Characteristics

TS Pump Suction Pressure _ _ _ D
TS Pump Discharge Pressure _ _ _ D
Lower Thermal Shield Flow _ _ _ D
Thermal Shield Coils Flow _ _ _ D
Upper Thermal Shield Flow _ _ _ D
Thermal Shield Expansion Tank Level _ _ _ D
Cleanup Flow _ _ _ D
Expansion Tank Circulating Loop Flow _ _ _ D
Circulating Pump Discharge Pressure _ _ _ D
Circulating Pump Suction Pressure _ _ _ D
Booster Pump Flow _ _ _ D
Booster Pump Discharge Pressure _ _ _ D

Booster Pump Suction Pressure				D	
Conductivity				D	
N_2 Purge Rate				D	
Heat Exchanger ΔT - TSCWS				D	
Heat Exchanger ΔT - Secondary				D	
Heat Exchanger ΔP - TSCWS				D	
Heat Exchanger ΔP - Secondary				D	
pH				D	/
Perform a TSCWS Walkthrough	P				/

5.4 THERMAL SHIELD AND COOLING WATER SYSTEM

LEARNING OBJECTIVES: Upon satisfactory completion of this section, the trainee will be able to:

1. State the purpose of the thermal shields and the thermal shield cooling water system.

2. List the major components of the thermal shields.

3. List the major components of the thermal shield cooling water system.

4. Locate the major components of the thermal shield cooling water system.

5. Describe the flowpaths of the thermal shield cooling water system:
   a. through the thermal shields
   b. through the thermal shield cooling water treatment system.

6. State the purpose of the thermal shield cooling water treatment system.

7. Describe the operation of the thermal shield cooling water system major components including:
   a. thermal shield cooling water pumps
   b. thermal shield cooling water treatment subsystem
   c. thermal shield cooling water coolers.

8. Describe the principles of thermal shield cooling water system operation during:
   a. startup
   b. normal operation
   c. shutdown

9. Explain the basis of the thermal shield cooling water system operating limits given a list of the limits.

10. State the automatic protective features and setpoints of the thermal shield cooling water system and explain the basis of each.

SYSTEM DESCRIPTION-THERMAL SHIELD AND COOLING WATER SYSTEM

1.0 Purpose

The purpose of this sytem is to remove the heat generated by radiation absorption in the components of the thermal shield.

2.0 General System Description

The thermal shield cooling system consists of two circulating water pumps, valves, a heat exchanger, an expansion tank, and a bypass flow cleanup system connected to the cooling circuits in the thermal shield to remove the heat generated by radiation absorption. There are three parallel flowpaths. Cooling water to the three flowpaths is adjusted by hand valves. These are the flowpaths to the coils imbedded in the lower thermal shield lead layer, the upper thermal shield, and the lower thermal shield. Figure 2-1 shows the thermal shield cooling system flow diagram. The coolant is light water.

The total water inventory in the thermal shield cooling system is 1350 gallons. The detailed inventory amounts are given in Table 2-1.

Water Inventory (gallons) in the Thermal Shield Cooling System

Table 2-1

Lower thermal shield	350
Upper thermal shield	100
Thermal shield pumps GA-201A and B	20
Thermal shield expansion tank (FA-201)	32
Thermal shield cooler (EA-201)	303
Piping, including lower shield cooling coil assemblies	545
TOTAL	1350

The thermal shield cooling system fluid is demineralized light water. A small side stream is passed through the thermal shield purification system to maintain the quality of the water. The purification stream is normally driven by the pressure difference across the thermal shield pumps, GA-102A and B. A cleanup booster pump is available to provide flow if the TSCS pumps are off. The purification system consists of filters, a mixed bed deionizer, and an ion exchanger to remove oxygen. The quality of the water is measured at conductivity meter CR-6 at a point where the three parallel flowpaths have joined. Figure 3-8 shows the clean up system flowpath.

Temperature changes in the system cause corresponding changes in volume. A 78-gallon expansion tank, FA-201, accommodates these changes in volume. A pressure-vacuum relief valve, SV-201, protects the expansion tank from system pressure surges. A makeup addition system is provided to ensure TSCS chemistry is maintained when adding water to the expansion tank.

The system is designed to operate on full flow from one of the two pumps, GA-201A and B, with the other standing by as a spare. The required total flow rate is 830 gpm, with 700 gpm to the lower thermal shield, 100 gpm to the upper thermal shield, and 30 gpm to the cooling coils in the lower shield.

3.0 Thermal Shield Cooling Water Component/Subsystem Description

The following paragraphs provide detailed descriptions of the various Thermal Shield Cooling System (TSCS) components. These components are shown in a detailed schematic diagram of the system provided in Figure 3-1. For a detailed description of TSCS instrumentation (pressure, temperature, flow, and level sensors), refer to 6.14 of the PDM.

3.1 Thermal Shield

3.1.1 Location

The thermal shield is located in the base of the heavy concrete pit, as shown in Figure 3-2. The thermal shield rests upon a circular I-beam support member imbedded in heavy concrete. The support girder, in turn, rests on the reinforced concrete structure of the experimental level. Immediately beneath the thermal shield there are a series of walls for the equipment cells in the basement which serve as load transmitting members to the foundation.

A 1-inch gap around the sides and bottom of the thermal shield ensures that thermal expansion is not restrained by the surrounding heavy concrete. The mounting pads on the thermal shield are radial steel plates that slide between guide bars on the support girder. This arrangement allows radial expansion of the shield but prevents rotation or linear motion. The thermal shield is maintained in a carbon dioxide atmosphere, both within the shield vessel and outside it in the radial and bottom gaps.

3.1.2 Construction

The thermal shield is composed of a multiple-walled cylindrical steel vessel and a three-component cover. A sketch of the assembled shield is shown in Figure 3-3. Details of the thermal shield vessel are shown in Figure 3-4, and details of the cover structure are shown in Figure 3-5.

The lower thermal shield is composed of a series of cylindrical steel shells, with water passages between some shells, and a shielding layer of lead between others. The composite wall is 9 in. thick, with 3 in. of steel plate, 1.25 in. of cooling water, and 4.75 in. of lead. The detailed structure of the side wall is shown in Figure 3-4. The bottom of the lower thermal shield is of the same type of construction, but with an increased water thickness due to the inner steel plate and flow baffle being dished heads rather than flat plates.

The basic dimensions of the lower thermal shield are 9 ft-0 in. outside diameter and over-all height 10 ft-6-3/4 in. The upper 26-3/4 in. of the shield vessel is an extension of the outer steel shell which serves as a tie ring for the hold-down bolts and wedges of the upper thermal shield. The lower thermal shield weighs 110,000 lbs, of which 70,230 lbs is due to the lead layer.

The cylindrical walls of the lower thermal shield are pierced by a series of holes which align with the beam tubes in the reactor vessel. The various neutron beams emerge from the thermal shield cavity through these holes. Cooling water enters and leaves the lower shield through a pair of 8 in. pipes in the bottom. The inlet pipe is on the shield centerline, and the outlet pipe is 16 in. off-center. A 1.5 in. pipe (1-1/2 in. DV-120) runs inside the inlet pipe and penetrates the inner head of the shield. This line is the CO_2 inlet pipe to the shield cavity and is also the water drain from the cavity.

Four thermocouple wells extend the full height of the lower shield in the lead layer. These wells can be reached from the shielded cells in the equipment area during shutdown periods.

The upper thermal shield is composed of three main pieces. The support ring is a toroidal box girder of rectangular cross section filled with steel shot and cooling water. The support ring provides substantial shielding, but its main purpose is structural support of the upper thermal shield assembly. The other components of the upper thermal shield are two split-ring sections. The assembled split-ring sections form a toroidal shield member with an L-shaped cross section. The base of the "L" is filled with layers of steel plates and cooling water passages. The vertical leg of the "L" is filled with steel shot and cooling water. The toroid is split on a vertical diametral plane to make the two split-ring sections. This complex construction was required so that the upper thermal shield could be assembled around the neck of the reactor vessel. Nozzles and flanges on the reactor vessel above the level of the upper thermal shield extend outside the diameter of the vessel neck, and prevent a simple, one-piece toroidal shield from being slid down over the completed vessel. The split-ring pieces, which are a close fit to the vessel neck, were assembled under the nozzles and flanges. The support ring, which is a single complete ring unit, has a sufficiently large inside diameter so that it passed over the reactor vessel flanges and nozzles during initial assembly.

The upper thermal shield section are bolted together to form a single unit. The reactor vessel, in turn, is bolted to this assembly. The upper thermal shield rests on a flange at the top of the lower thermal shield, and is held in place by a series of hold-down bolts and wedges which lock into the extended outer shell of the lower shield.

The basic dimensions of the upper thermal shield are 8 ft-9 in. outside diameter, 4 ft-4 in. inside diameter, and 1 ft-8 in. height. These dimensions are for the assembled shield rather than the component parts. The assembled upper thermal shield weighs 30,000 lbs. The upper thermal shield assembly is penetrated by three holes for the thermal irradiation thimbles. In addition, there is a hole for the installation of a thermopile assembly into the shield cavity.

The basic material of the upper and lower thermal shields is carbon steel. The lower thermal shield contains a layer of lead for shielding. Embedded in the lead is welded steel cooling piping. The upper thermal shield contains steel shot and steel plate for shielding. Brass pipe and fittings are used for the thermocouple wells imbedded in the lead layer.

3.1.3 Operation

The primary function of the thermal shield is to protect the surrounding heavy concrete structure from excessive heating by radiation leakage from the reactor. The heavy concrete used in the HFBR shield will accept an energy current density of 7.5×10^{11} MeV/cm^2-sec (giving a maximum temperature rise of 10°C) without thermal stress cracking. The energy current from the active core is about 8×10^{13} MeV/cm^2-sec at the shield surface, and the thermal shield must attenuate this current to the value above if the concrete is not to crack.

A second important function of the thermal shield is to support the reactor vessel. The reactor vessel is bolted to the upper thermal shield. The weight of the vessel is carried by the thermal shield and is transmitted to the foundations through the shield support ring.

An auxiliary function of the thermal shield and its cover is to provide containment for heavy water leakage from the reactor vessel. The thermal shield cover (upper thermal shield) also acts as the primary shielding layer for the refueling pit area.

3.2 Thermal Shield Cooling Water Pumps

3.2.1 Location

Thermal Shield Cooling Water Pumps GA-201A and GA-201B, are located on the equipment level, north side. See Figure 2-1 of PDM Section 1.2.

3.2.2 Construction

The two pumps, GA-201A and B, used in the thermal shield cooling system are of the vertical, one-stage, centrifugal type designed for in-line installation. Table 3-1 summarizes information on these pumps.

Characteristics of the Thermal Shield Cooling System Pumps GA-201A and B

Table 3-1

Manufacturer	Pacific Pumps, Inc.
Flow Data	
design	800 gpm at 47 ft
test	800 gpm at 51 ft
Impeller	11-3/4 in. diameter, enclosed type
RPM	1185
Motor	Louis Allis, 15 hp, 3 phase, 440 volts, 60 Hz
NPSH at rated flow	4 ft
Materials of Construction	Case of nodular iron, impeller of cast iron, shaft of Chromemoly steel, wear parts of Stainless Steel
Seals	One per pump, similar to seal used in the primary pumps

3.2.3 Operation

The two thermal shield cooling water pumps each have a disconnect switch with a green pilot light to signify when the power is off mounted adjacent to each pump motor. Normally one of the pumps is running. The selection of the running pump and the standby pump is made on two 3-position selector switches mounted on the reactor control console. The selector switches have three positions, HAND-OFF-AUTO. When one of the selector switches is set on HAND and the other on AUTO, the pump in the HAND position will run continuously and the one on AUTO will start up automatically in the event the running pump fails. It is possible to run both pumps by placing both selector switches in the HAND position.

3.2.4 Indications

Pump status indicating lights are provided in the control room to inform the operator of TSCS pump status.

3.2.5 Power Supplies

Power for the thermal shield pump motors is derived from a 440-volt, 3-phase breaker in motor control center MCC-1.

3.3 Thermal Shield Cooler EA-201

3.3.1 Location

Thermal Shield Cooler EA-201 is located on the equipment level next to the thermal shield cooling water pumps. See Figure 2-1 of PDM Section 1.2.

3.3.2 Construction

The thermal shield cooler, EA-201, is a "U" tube type mounted horizontally. Table 3-2 presents data on the cooler.

Thermal Shield Cooler (EA-201) Data

Table 3-2

Vendor	Southwestern Engineering Co.
Shell side fluid	Demineralized H_2O
Tube side fluid	Cooling tower water
Rated flow, normal service	
Shell side	700 gpm, 20% overdesign
Tube side	400 gpm, 20% overdesign
Design temperature	150°F
Design pressure	
Shell side	75 psig
Tube side	75 psig
Materials of construction	
Tubes (390 U-Tube 3/4" O.D.)	SB-111 Admiralty Brass
Shell	Steel
Tube sheet	SB-171 Naval Rolled Brass
Channel	Steel
Channel cover	Steel
Closure design	All closures are gasketed joints except tube to tube sheet joints are rolled

3.3.3 Operation

At times it may be necessary to operate both pumps simultaneously. The flow rate in this case may be above the cooler design level. To provide for this situation, a bypass around the cooler has been installed. The bypass performs another service: with the reactor shut down and low temperature water arriving from the cooling tower, it allows control of the cooler outlet water temperature. (The same thing can be accomplished by throttling the cooling tower supply valve.)

3.4 Thermal Shield Cooling Water Expansion Tank (FA-201)

3.4.1 Location

The Thermal Shield Cooling Water Expansion Tank (FA-201) is located on the operations level in the greenhouse. See Figure 2-6 of PDM Section 1.2.

3.4.2 Construction

The thermal shield expansion tank, FA-201, is constructed of carbon steel. It is a cylindrical tank 20 in. outside diameter and 61 in. length, with a total capacity of 78 gallons. The bottom outlet is to the thermal shield and the top outlet is to safety valve SV-201, which vents to the off-gas system. A sight glass for level indication is installed at the central section of the tank.

3.4.3 Operation

The thermal shield cooling water system removes radiation heat generated by the reactor. Due to the various operating modes of the reactor, the system experiences varying heat loads. As the heat load changes, system volume changes. The expansion tank is provided to accommodate these changes. A pressure-vacuum relief valve, SV-201, protects the expansion tank from system pressure surges. The valve, SV-201, has a low pressure setpoint of 0.125 psi vacuum and a high pressure setpoint of 2 psig. A bypass valve that is always open around SV-201 is provided to allow the nitrogen sparge gas to vent.

3.5 Thermal Shield Cooling Water Expansion Tank Treatment Subsystem

3.5.1 Location

The TSCS expansion tank treatment subsystem is located on the operations level, near the greenhouse.

3.5.2 Construction

Table 3-3 lists the major components of the TSCS expansion tank treatment subsystem with corresponding construction data.

Thermal Shield Water Treatment System Component Data

Table 3-3

Component	Data
Expansion Tank Circulating Water Pump	Goulds Pumps Inc., Model 3199 horizontal, single-stage centrifugal pump
Dissolved Oxygen Analyzer	Hays Corp., Model 625

3.5.3 Operation

Makeup to the thermal shield cooling water system is usually made through the expansion tank and normally comes from a 30-gallon makeup tank containing demineralized water adjusted to pH 10 and sparged with purified nitrogen to remove air.

Dissolved oxygen in the cooling water is maintained at very low levels by continuous sparging of the expansion tank with purified nitrogen. System water is circulated through the expansion tank at 3 gpm using a centrifugal pump. Dissolved oxygen concentration as monitored by a dissolved oxygen analyzer is normally less than 1 part per billion (ppb).

3.5.4 Indications

Indicators associated with the TSCS expansion tank water treatment system are as follows:

Indication	Location
Conductivity meter (CR-6)	Panel No. 2 control room
Dissolved oxygen analyzer	outside greenhouse, operations level

3.5.5 Power Supplies

The expansion tank circulating water pump receives power from a 120 volt electrical outlet in the equipment level. The dissolved oxygen analyzer receives power from a 120 volt power supply outlet in the operations level.

3.6 Thermal Shield Cooling System Purification Subsystem

3.6.1 Location

The TSCS purification subsystem is located on the equipment level, north side by the shutdown cooler pit.

3.6.2 Construction

The TSCS purification subsystem consists of filters, one LiOH resin bed; one hydroxyl form anion bed and an Integral Motor Pump Corporation Series 1000 seal-less centrifugal pump. A third tank in parallel with the two resin beds is available for use as an HOH bed for pH reduction or an LiOH bed for additional purification capacity.

3.6.3 Operation

The thermal shield cooling system fluid is demineralized light water which is adjusted to between pH 10 and 11 by addition of LiOH. The quality of the water is measured by a conductivity meter (CR-6) at a point where the three parallel circuits are joined and by an on-line dissolved oxygen analyzer which samples system water at the expansion tank. System pH is maintained between pH 10 and pH 11 by one of the following means:

pH reduction - The system pH may be reduced by draining coolant and replacing it with neutral pH water from the makeup subsystem. System pH can also be reduced by filling resin tank number 3 with HOH resin and diverting a sidestream of thermal shield coolant through it.

pH increase - The thermal shield coolant pH can be increased by metering lithium hydroxide into the expansion tank.

Grab samples are periodically taken and analyzed to confirm the system pH. Adjustments to system pH are made by addition of neutral makeup water or by slug feeding of LiOH solution. See Figure 3-6.

A small side stream of 3 to 5 gpm is passed through the thermal shield purification system to maintain the quality of the water. The purification stream is driven by the pressure difference across the thermal shield pumps (GA-102A and B). A centrifugal pump is installed in the cleanup loop to provide circulation when the thermal shield circulating pumps are off.

3.6.4 Indications

All indications associated with the TSCS purification subsystem are local and are listed in Table 3-4.

TSCS Purification Subsystem Indications

Table 3-4

Indicator	Range
Inlet filter inlet pressure gauge	0 - 160 psi
Inlet filter outlet pressure gauge	0 - 160 psi
Outlet filter outlet pressure gauge	0 - 160 psi
Outlet filter inlet pressure gauge	0 - 160 psi
Purification subsystem flow meter	.6 - 12 gpm

4.0 Principles of Operating Procedures

4.1 Thermal Shield Cooling Water System Startup

Startup procedures include filling the thermal shield water cooling system (TSWCS) and bringing the system to its normal operating level.

Prior to starting up the TSWCS, it must be filled to a volume where the expansion tank level sightglass indicates greater than half full. If the sightglass shows a level less than half full, water must be added from the domestic water makeup system.

The TSWCS expansion tank vent valve is opened while filling the system to allow air to escape so as not to overpressurize the tank. All the TSWCS drain valves are shut or checked shut to ensure system integrity. Except in an emergency, system makeup should not be from the auxiliary purification system (BG-201). The expansion tank should be filled with deionized water from the makeup subsystem. This makeup water should be sparged with purified nitrogen to remove dissolved oxygen and adjusted to a pH of approximately 10 by the addition of lithium hydroxide. Corrosion is minimized in the thermal shield system piping by maintaining coolant pH between 10 and 11, and by reducing the quantities of dissolved oxygen and chlorides in the coolant.

Support systems that must be in operation prior to TSWCS startup are the secondary cooling water system, which supplies cooling water to the TSCWS coolers and the demineralized water system, which supplies makeup water to the TSCWS. The reactor building compressed air system must be in operation for the TSCWS pneumatic coolant flow and level instrumentation, nitrogen from a nitrogen cylinder is required when the expansion tank is purged, and the building off-gas system removes vented gasses from the TSCWS expansion tank. AC electrical power must be available to energize the TSCWS pumps, TSCWS cleanup loop booster pump, and for associated instrumentation.

The TSCWS is started up by fully opening the TSCWS cooler secondary water discharge valve and opening the supply valve approximately 10% so as not to excessively cool down the TSCWS and establish the heat removal capability of the cooler. The TSCWS pumps (GA-201A and B) suction valves are fully open to establish a flow to the pumps. The TSCWS lower shield supply valve is opened to establish lower shield cooling water.

At the control room console, pump GA-201A or B is selected to "Run" and the other to "Standby" to ensure a pump is always running. Each pump is then run and the discharge valve for each is set to establish proper flow to the cooling coils, upper thermal shield, and lower thermal shield. Pump differential pressure is also checked after proper shield flows are established to ensure the system is not fouled.

The TSCWS water treatment system is then placed on the line to ensure proper system pH and conductivity, and the TSCWS expansion tank circulating pump is started to prevent chemical stratification in the expansion tank.

4.2 TSCWS Normal Operation

After one TSCWS pump is started and the other is placed in standby and system flows have been adjusted, the secondary cooling water supply valve is throttled as necessary to maintain TSCWS temperature below 55°C.

The TSCWS cooling pump control circuits automatically cause the standby pump to start if the running pump trips. If the running pump trips and is then restarted, the standby pump automatically stops and resumes its standby function.

The pumps are not normally switched when the reactor is operating. If the standby pump discharge valve has been throttled to the proper position, the standby pump should be started before switching the running pump off. With both pumps operating, the discharge valve on the standby pump is opened until the following flow indications are obtained for the three legs of the system: FRa-201 approximately 830 gpm, FI-207 approximately 37 gpm, FI-202 approximately 120 gpm. These are the system flows with both pumps operating and discharge valves properly throttled. The original run pump is then stopped and placed in standby.

4.2.1 Normal System Parameters

Table 4-1 lists thermal shield cooling water indications and their normal operating parameters.

Thermal Shield Cooling Water Normal Operating Parameters

Table 4-1

Parameter	Normal Reading
Lower Thermal Shield Flow	700 gpm
Thermal Shield Coils Flow	30 gpm
Upper Thermal Shield Flow	100 gpm
Thermal Shield Expansion Tank Level	15"
Cleanup Loop Flow	3 gpm
Expansion Tank Circulating Loop Flow	3 gpm
* Coolant Conductivity	30-270 µmhos/cm
Nitrogen Purge Rate to Expansion Tank	100 cm^3/min @ 5 psi supply pressure
Operating temperature	
Shell side in	125°F
Shell side out	112°F
Tube side in	85°F
Tube side out	108°F
Operating pressure	
Shell side	5 psig
Tube side	45 psig

* pH is determined by referring to Figure 4-1 using conductivity data taken from control room instrumentation.

4.3 TSCWS Shutdown

The system cannot be shut down when the reactor is operating because loss of the system will initiate a setback. The system is normally shut down by turning off both pumps.

4.4 TSCWS Cleanup Subsystem Maintenance

When maintenance is to be performed on any component of the thermal shield cleanup loop, which involves breaking open the system, Safety and Environmental Protection personnel must be consulted to establish precautionary measures and guidance.

When conducting maintenance on the TSCWS cleanup subsystem, carefully follow the written procedures in the Operations Procedures Manual (OPM). Because they are infrequently performed, maintenance procedure valve lineups must be checked to ensure that proper flowpaths are established. This will prevent chemical spills and cross-system contamination. Radiation control procedures should also be followed because radioactive contaminants migrate from the high flux area to components external to the thermal shield.

4.5 System Operating Restrictions

4.5.1 System Operating Parameters

The limiting parameters associated with the TSCWS are listed in Table 4-2. The minimum thermal shield flow limits and temperatures are set to ensure that enough cooling water is supplied to the shield to remove radiation heat to prevent damage due to overheating. The cooler flow rate and pressure limits are established to protect the heat exchanger from overstress. The maximum expansion tank level can indicate insufficient room for expansion without possibly overflowing water into the offgas system, while the minimum level can indicate a thermal shield system coolant leak. Maximum dissolved oxygen, minimum makeup water resistivity, and cleanup filter D/P are established to ensure proper thermal shield cleanup loop operation and water chemistry, prevent filter blowout, minimize system corrosion, and reduce activation products. Figure 4-1 is a graph of system conductivity vs. cooler outlet temperature for pH 10 and pH 11.

Thermal Shield Cooling System Limiting Parameters

Table 4-2

Exceptions	Operating Variable	Mode of Reactor Operation	Reactor Operating Limit	System Operating Limit
1	Minimum Lower Thermal Shield Coolant Flow	All	600 gpm	----
1	Minimum Upper Thermal Shield Coolant Flow	All	60 gpm	----
1	Minimum Cooling Coil Flow	All	20 gpm	----
None	Maximum Cooler Primary Flow	All	----	840 gpm
None	Maximum Diff. Press. Across Cleanup Filters	All	----	35 psi
None	Maximum Cooler Primary Pressure	All	----	75 psig
None	Maximum Cooling Circuit Outlet Temperature	All	60°C	----
None	Maximum Expansion Tank Liquid Level	All	19 inches	----
None	Minimum Expansion Tank Liquid Level	All	1 inch	----
None	Maximum Dissolved Oxygen Concentration	All	----	5 ppb
None	Minimum System Makeup Water Resistivity	All	----	0.2 megohm-cm

1 Exceptions to these limits are permitted for 15 second outages during switching of pumps.

Coolant pH - To be maintained between 10.0 and 11.0 as determined from the "Thermal Shield Coolant Conductivity vs. Cooler Outlet Temperature Curve" in Figure 4-1.

The LiOH mixed beds in the cleanup loop shall be changed when less than 50% of the gross beta, gamma activity of the water flowing through the loop is removed by the beds when the reactor is operating, as determined by the water chemistry laboratory.

The OH anion bed shall be changed when the chloride content in the water exceeds 100 ppb, as determined by the water chemistry laboratory.

4.5.2 Consequences of Improper Operation

One probable error more likely encountered during startup of the TSCWS is a failure to ensure system integrity. The result would be a loss of TSCWS inventory. Indications of this would be a low liquid level in the expansion tank. This could cause reduced heat removal capability and increased thermal stresses on the thermal shield.

Another error would be to allow TSCWS pH to fall from the control band of 10 to 11 while filling the system. Indications of this would be on conductivity meter C-6. This could cause increased system corrosion.

During normal operations regular observation of TSCWS pump operation and flow is necessary to detect impending problems. The standby TSCWS pump will not start automatically as long as the running pump is still energized, even though the running pump may not be delivering full flow due to some malfunction. Therefore, less-than-normal flow would not be detected until the TSCWS low flow alarms or reactor setback are activated unless operator surveillance is at a high level.

The thermal shield must have coolant flow when the reactor is running. Loss of coolant flow initiates a setback of the reactor. A two out of three setback logic is formed from the two pump breakers and FRa-201. Each of these is annunciated in the control room. For the normal one pump operation the logic becomes one out of two. If the loss of flow is caused by a failure of the running pump, the second pump will start. As soon as proper flow has been reestablished, the setback condition will be terminated and the operator can take steps to bring the reactor back to power.

In the event of the loss of both thermal shield pumps the reactor will continue in setback condition until all control rods are fully inserted.

** Denotes material extracted from a controlled copy of the HFBR OPM.

SELF-STUDY QUESTIONS - THERMAL SHIELD COOLING WATER SYSTEM

1. **The purpose of the thermal shield cooling water system is to:**

   a. Remove heat generated by radiation absorption in the beam port plug and beam port shutters.
   b. Remove heat generated by radiation absorption in the components of the thermal shield.
   c. Remove heat generated by radiation absorption in the fast and thermal irradiation thimbles.
   d. Provide containment for heavy water leakage from the reactor.

2. **The primary purpose of the thermal shield is to:**

   a. Reduce radiation from the reactor core to an acceptably low level for human tolerance.
   b. Reduce radiation absorption in the fast and thermal irradiation thimbles.
   c. Protect the surrounding heavy concrete structure from excessive heating by radiation leakage from the reactor.
   d. Protect the biological shield from excessive heating by radiation leakage from the reactor.

3. **Adjustments to thermal shield cooling water system pH are made by:**

   a. Addition of sulphuric acid and water.
   b. Feed and bleed with lithium hydroxide.
   c. Placing additional resin beds on line.
   d. Addition of water and slug feeding of lithium hydroxide.

4. **The normal operating configuration for the thermal shield cooling water pumps is:**

   a. Both pumps running.
   b. Both pumps in standby, operating as heat load dictates.
   c. One pump running, one pump in standby.
   d. As determined by the shift supervisor.

5. **The thermal shield cooling water system receives makeup water from:**

   a. A 30-gallon makeup tank containing demineralized water.
   b. Auxiliary water purification system (BG-201).
   c. Thermal shield cooling water purification system.
   d. Domestic water system.

6. **Thermal shield cooling water system pH is maintained between 10-11 to:**

   a. Increase ability of water to remove heat.
   b. Increase ability of thermal shield cooling water to attenuate radiation.
   c. Reduce system corrosion due to water exposure.
   d. Prevent excessive wear of pump impeller and cooler tubes.

7. **Loss of thermal shield coolant flow initiates:**

   a. A reactor setback.
   b. A reactor scram.
   c. An alarm only.
   d. Startup of the standby thermal shield cooling water pump.

ANSWERS

1.	b	Section 1.0
2.	c	Section 3.1.3
3.	d	Section 3.6.3
4.	c	Section 3.2.3
5.	a	Section 3.5.3
6.	c	Section 4.1
7.	a	Section 4.5.2

References - Section 5.4

1. HFBR Plant Description Manual
    - a. 5.2, Secondary Cooling Water
    - b. 6.14, Thermal Shield Cooling Water Instrumentation System

2. HFBR Operations Procedure Manual
    - a. 2.1 and 2.2, Safety Rules and Limits
    - b. 5.4, TSCWS Operating Procedures
    - c. 6.10, TSCWS Instrumentation

3. HFBR Final Safety Analysis Report (FSAR)
    - a. FSAR Section 7.9, Thermal Shield Cooling System
    - b. 1978 FSAR Addendum, Section 7.9-2, Thermal Shield System Oxygen and pH Control System
    - c. 1978 FSAR Addendum, Section 7.9.6.2, Thermal Shield Cooler

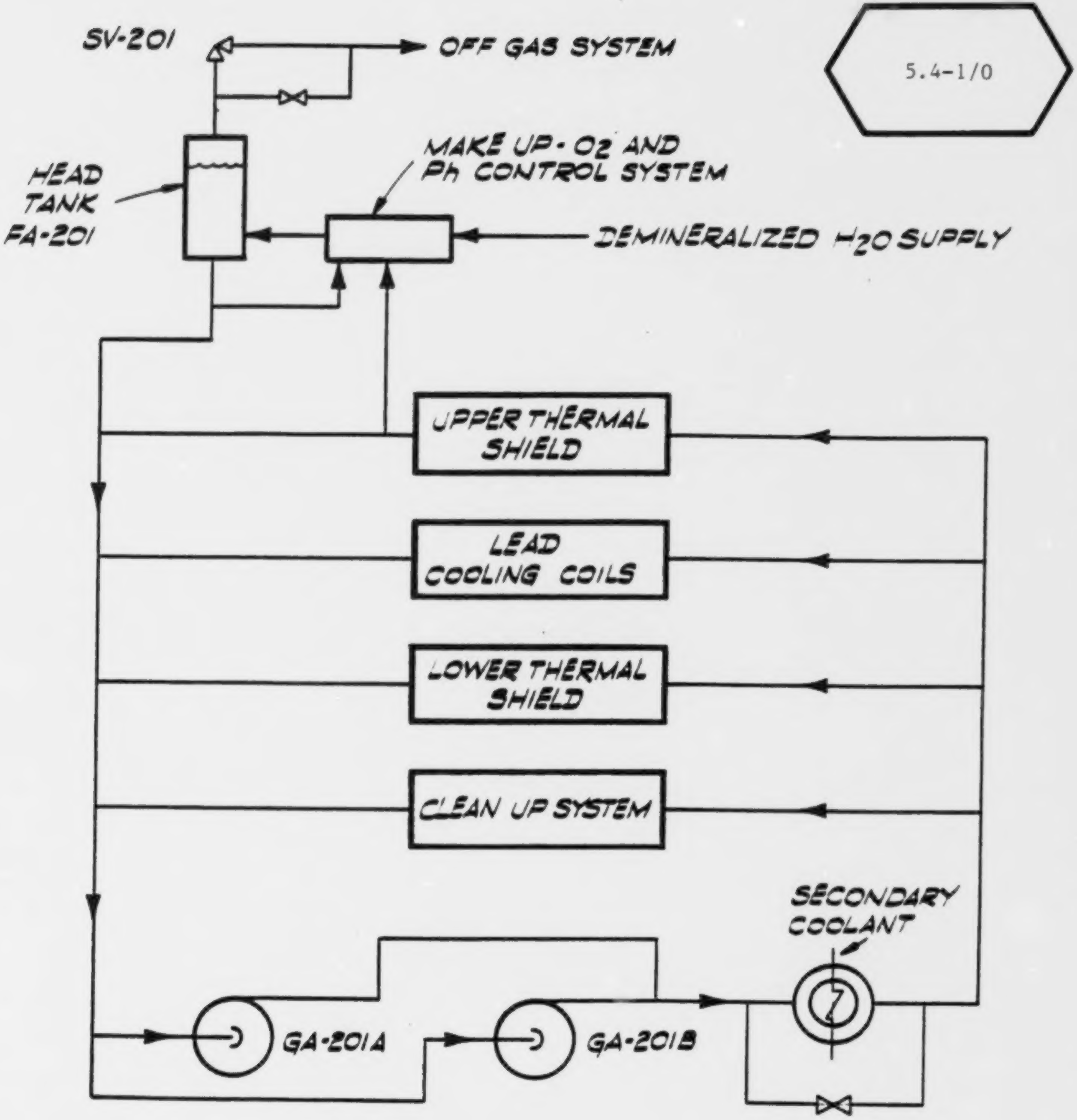

SV-201
OFF GAS SYSTEM
5.4-1/0
MAKE UP - O2 AND
Ph CONTROL SYSTEM
HEAD
TANK
FA-201
DEMINERALIZED H2O SUPPLY
UPPER THERMAL
SHIELD
LEAD
COOLING COILS
LOWER THERMAL
SHIELD
CLEAN UP SYSTEM
SECONDARY
COOLANT
GA-201A
GA-201B

Figure 2-1
Thermal Shield Cooling System Simplified Drawing

5.4-2/0

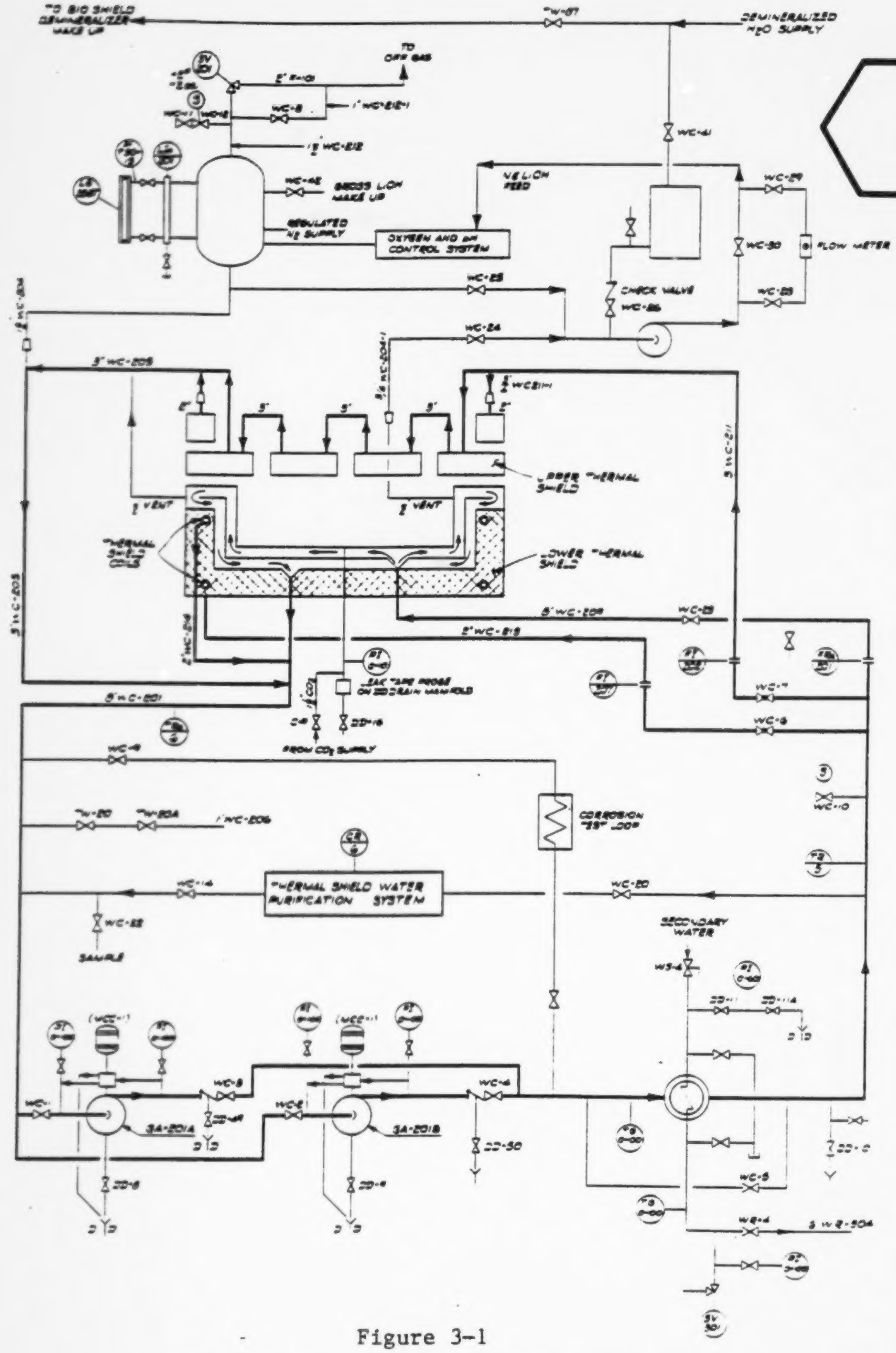

TO BIO SHIELD DEMINERALIZER MAKE UP
DEMINERALIZED H2O SUPPLY
TO OFF GAS
SV 101
2" E-101
WC-8
1" WC-212-1
1½" WC-212
WC-42
LiOH MAKE UP
REGULATED N2 SUPPLY
OXYGEN AND pH CONTROL SYSTEM
LiOH FEED
WC-41
WC-29
WC-30
FLOW METER
WC-25
CHECK VALVE
WC-26
WC-28
WC-24
3" WC-205
¾" WC-211-1
2"
3"
UPPER THERMAL SHIELD
½" VENT
THERMAL SHIELD COILS
LOWER THERMAL SHIELD
3" WC-211
3" WC-203
2" WC-214
3" WC-209
WC-23
2" WC-213
LEAK TAPE PROBE ON DD DRAIN MANIFOLD
DD-16
FROM CO2 SUPPLY
3" WC-201
WC-7
WC-6
WC-19
WC-20
WC-20A
1" WC-206
CORROSION "SS" LOOP
WC-10
THERMAL SHIELD WATER PURIFICATION SYSTEM
WC-14
WC-20
WC-22
SAMPLE
SECONDARY WATER
WS-4
DD-11
DD-11A
WC-1
WC-3
WC-2
WC-4
SA-201A
SA-201B
DD-50
DD-8
WC-5
WS-4
3" WS-504
SV 301

Figure 3-1

Detailed Thermal Shield Assembly Flow Diagram

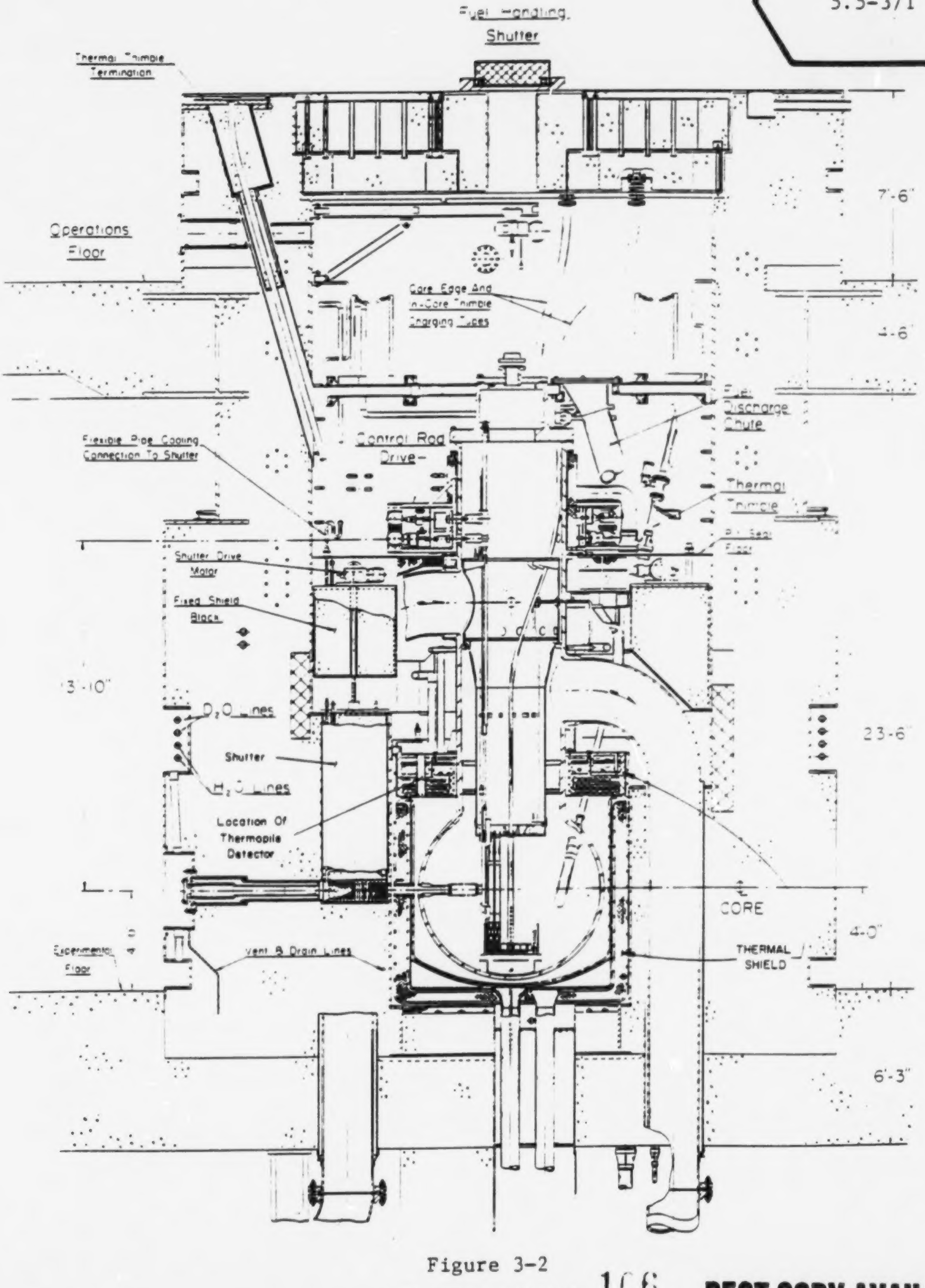

Fuel Handling Shutter
Thermal Thimble Termination
Operations Floor
Core Edge And In-Core Thimble Charging Tubes
7'-6"
4'-6"
Fuel Discharge Chute
Control Rod Drive
Flexible Pipe Cooling Connection To Shutter
Thermal Thimble
Air Seal Floor
Shutter Drive Motor
Fixed Shield Block
13'-10"
D_2O Lines
Shutter
H_2O Lines
23'-6"
Location Of Thermopile Detector
CORE
4'-0"
Experimental Floor
Vent & Drain Lines
THERMAL SHIELD
6'-3"

Figure 3-2
Thermal Shield

BEST COPY AVAILABLE

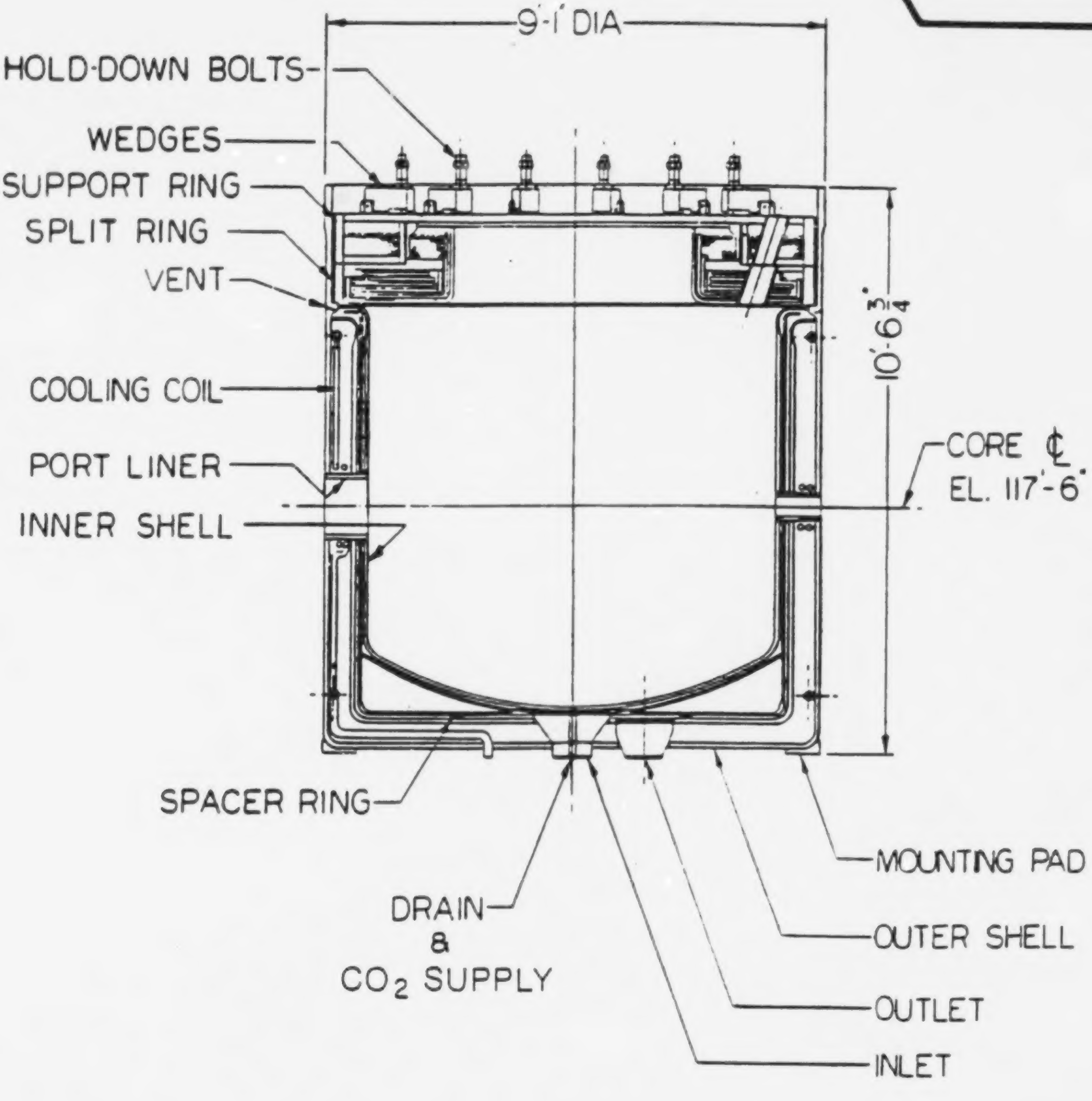
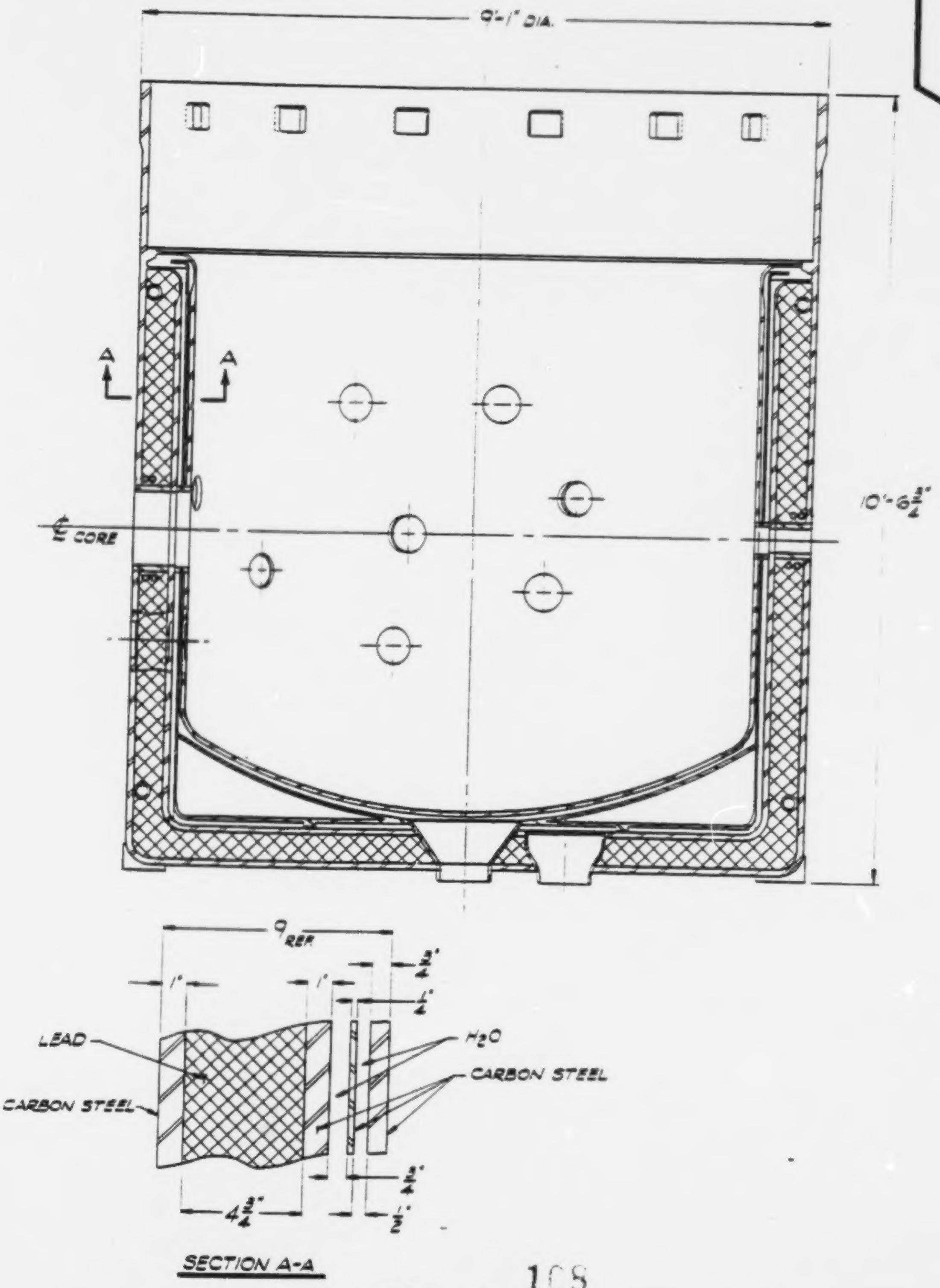

9'-1" DIA
HOLD-DOWN BOLTS
WEDGES
SUPPORT RING
SPLIT RING
VENT
COOLING COIL
PORT LINER
INNER SHELL
10'-6¾"
CORE ℄
EL. 117'-6"
SPACER RING
MOUNTING PAD
OUTER SHELL
OUTLET
INLET
DRAIN & CO_2 SUPPLY

Figure 3-3
Thermal Shield Assembly


9'-1" DIA.
A
A
℄ CORE
10'-6¾"
9 REF
1"
1"
¾"
¼"
LEAD
H₂O
CARBON STEEL
CARBON STEEL
¾"
4¾"
½"
SECTION A-A

108

Figure 3-4

Lower Thermal Shield Elevation

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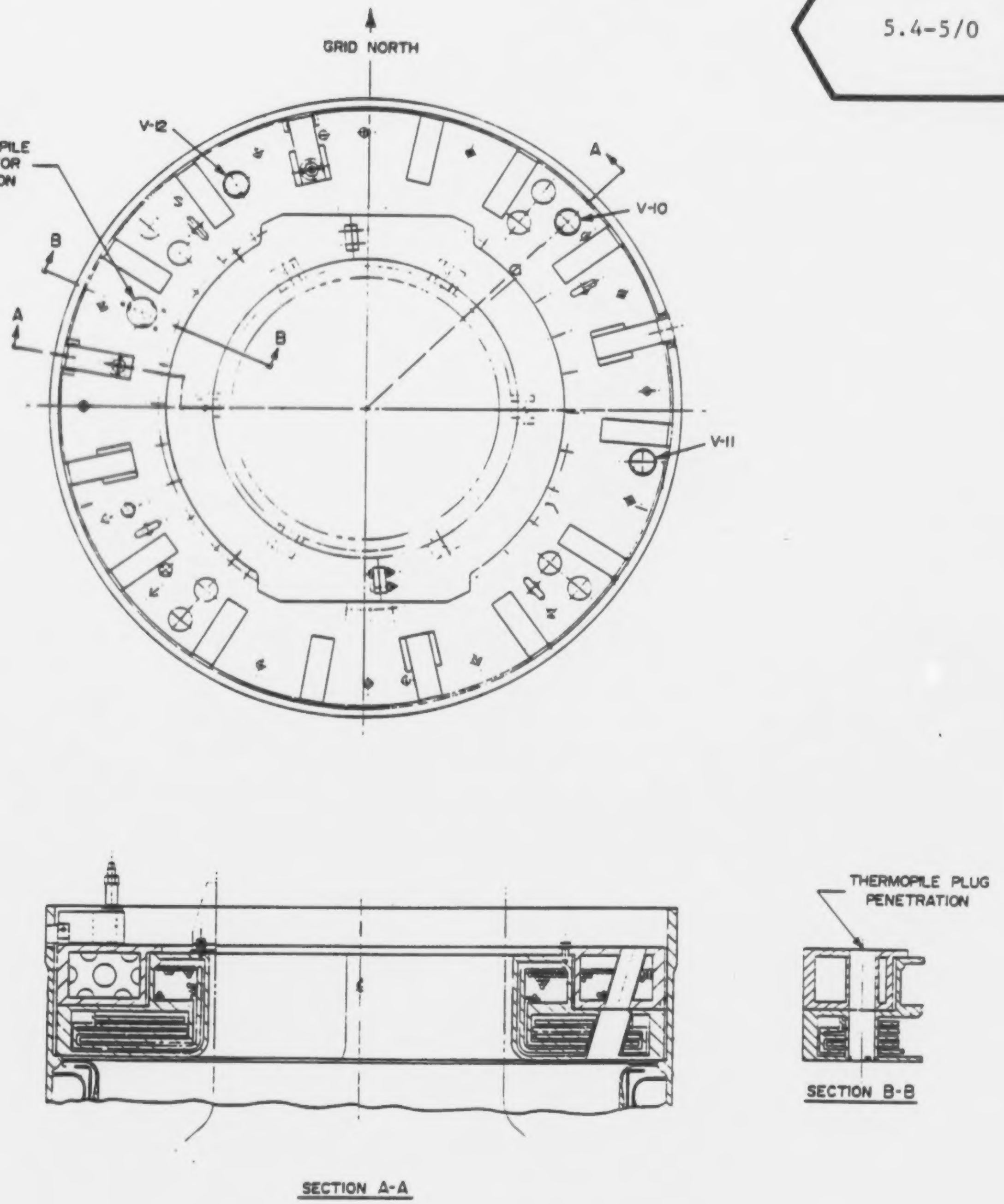
GRID NORTH
THERMOPILE DETECTOR LOCATION
V-12
V-10
V-11
A
A
B
B
THERMOPILE PLUG PENETRATION
SECTION A-A
SECTION B-B

Figure 3-5

Upper Thermal Shield Assembly

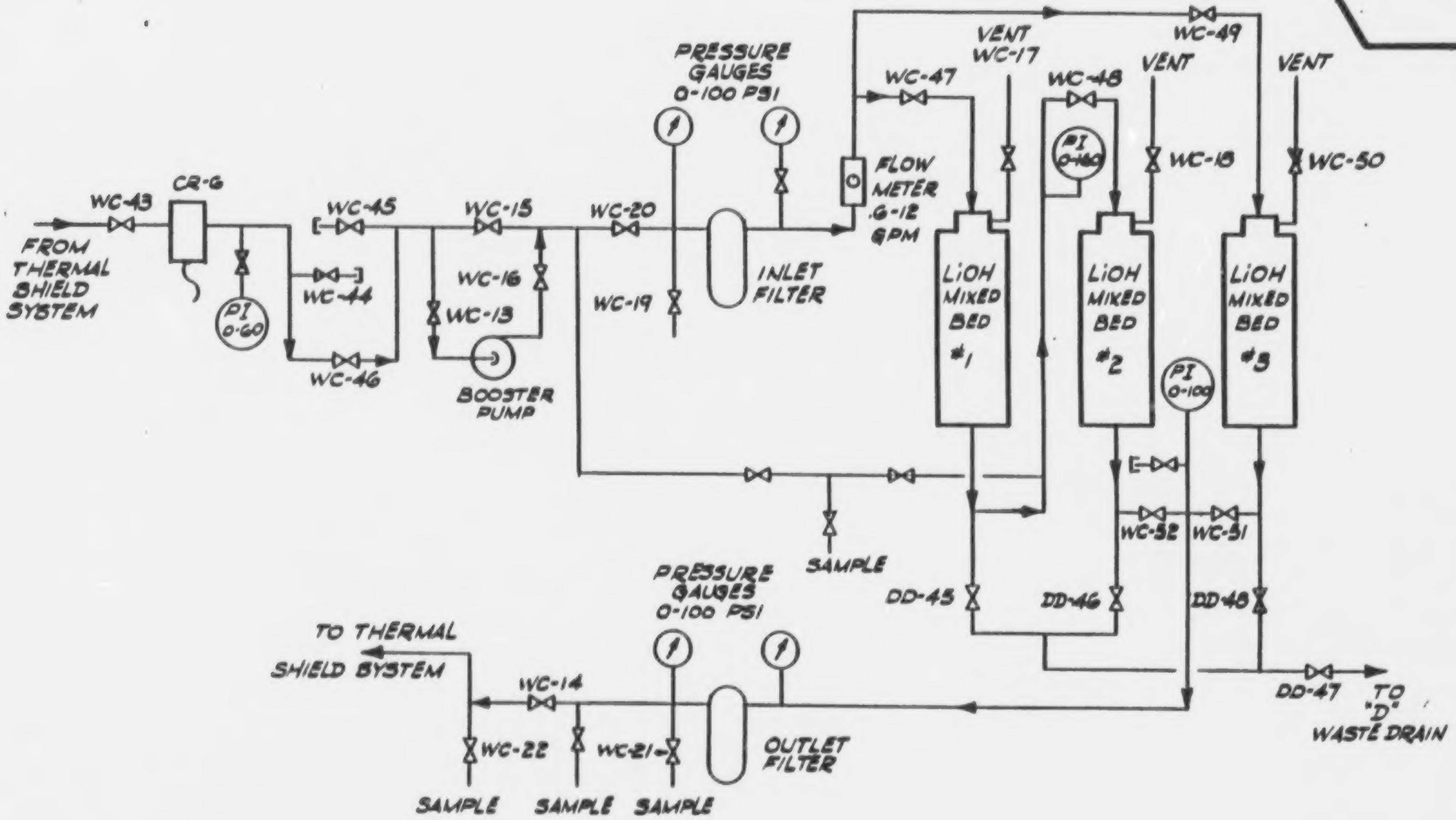
FROM THERMAL SHIELD SYSTEM
WC-43
CR-6
PI 0-60
WC-45
WC-44
WC-46
WC-15
WC-16
WC-13
BOOSTER PUMP
WC-20
WC-19
PRESSURE GAUGES 0-100 PSI
INLET FILTER
FLOW METER .6-12 GPM
WC-47
VENT WC-17
WC-48
PI 0-160
VENT
WC-18
WC-49
VENT
WC-50
LiOH MIXED BED #1
LiOH MIXED BED #2
LiOH MIXED BED #3
PI 0-100
SAMPLE
WC-52
WC-51
DD-45
DD-46
DD-48
DD-47
TO "D" WASTE DRAIN
TO THERMAL SHIELD SYSTEM
WC-14
PRESSURE GAUGES 0-100 PSI
OUTLET FILTER
WC-22
WC-21
SAMPLE
SAMPLE
SAMPLE

Figure 3-6

Thermal Shield Cleanup System

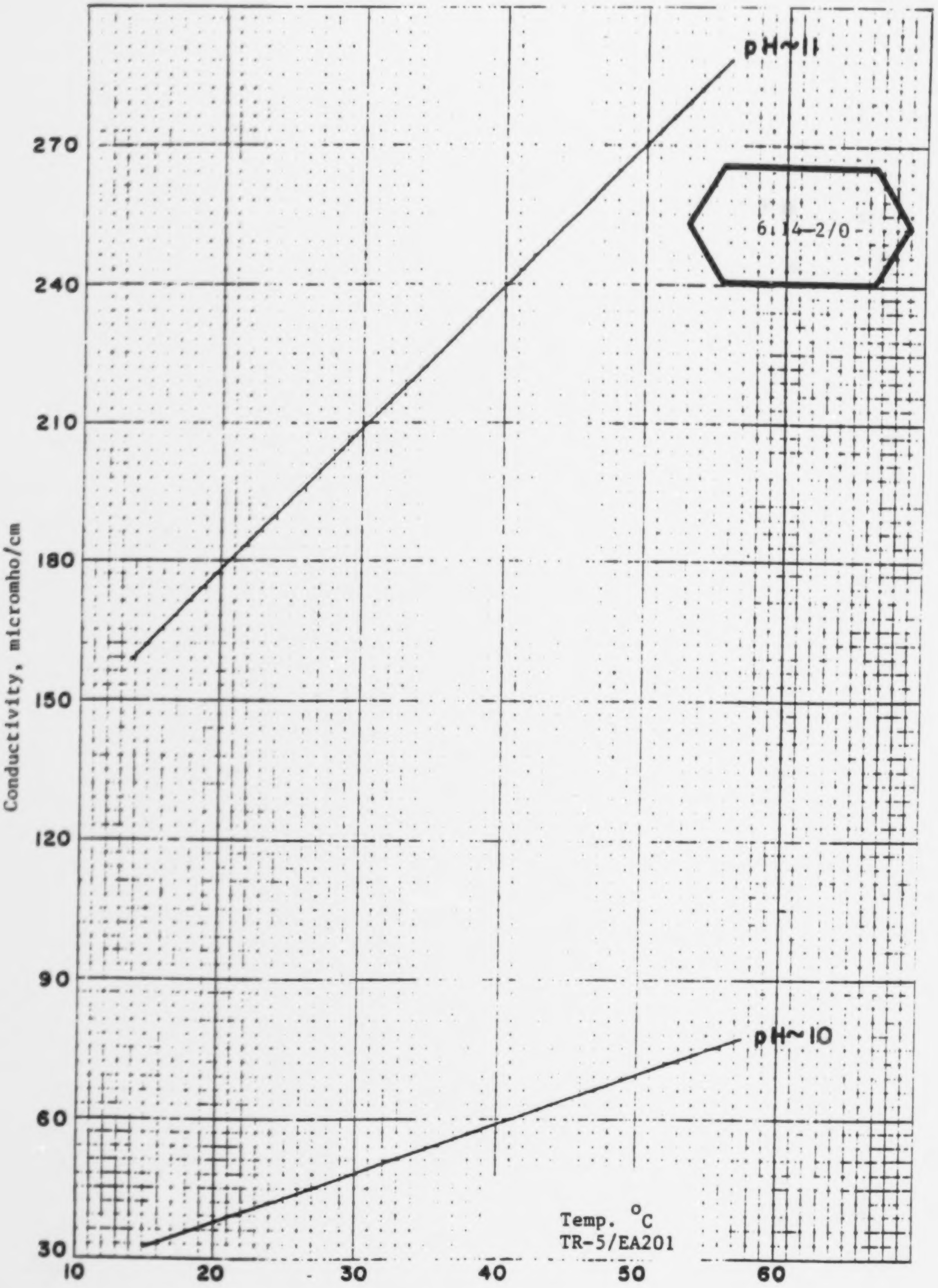

Figure 4-1
TS Coolant Conductivity vs. Cooler Outlet Temperature

REFERENCES:
HFBR OPM 5.4

F 5.4 THERMAL SHIELD COOLING SYSTEM OPERATING PROCEDURE

	TASK	P	S	O	D	Evaluator / Date
1.0	Discuss "System Operating Restrictions"				D	/
2.0	Perform TSCS Startup Procedure					
2.1	"Normal or Extended Shutdown"	P				/
2.2	"Short Duration Shutdown"	P				/
3.0	Perform "TSCS Shutdown Procedure"					
3.1	"Routine Shutdown"	P				/
3.2	"Extended Shutdown"	P				/
4.0	Perform "Switching Pumps with One Pump Operating"	P				/
5.0	Perform "Two Pump Operation"	P				/
6.0	Perform "TSCS Normal Operating Instructions"					
6.1	"Modes of TS Cleanup Loop Operation"	P				/
6.2	"TS Cleanup Loop Normal Operating Values"	P				/

6.3	"Expansion Tank Circulating Loop Normal Operating Valves"	P _ _ _	________/______
7.0	Perform Putting TS Cleanup Loop in Operation		
7.1	"Prestartup Check"	P _ _ _	________/______
7.2	"System Startup"	P _ _ _	________/______
8.0	Perform "Removing the TS Cleanup Loop from Operation"	P _ _ _	________/______
9.0	Perform "Normal System Makeup"	P _ _ _	________/______
10.0	Perform "Gross Makeup"	P _ _ _	________/______
11.0	Perform "Filling Makeup Tank with Domestic Water"	P _ _ _	________/______

HFBR Operations Procedures Manual

5.4 THERMAL SHIELD COOLING SYSTEM OPERATING PROCEDURES

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Hand Processed Changes

HPC No.	Date	Page Nos.	Initials

HPC 2-91/Revision No. 32 approved by:

Michael H Brooks 1/7/91
Reactor Division Manager Date

5.4 Thermal Shield Cooling System Operating Procedures

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	1.2	System Operating Parameters	1
	1.3	System Relief Valve Settings	1
	1.4	System Alarm Settings	1
	1.5	System Startup and Shutdown Procedures	1
	1.6	pH Control and Cleanup Loop Maintenance Procedures	1
	T1	Table of Thermal Shield Cooling System Limiting Parameters (5.4-1)	2
	T2	Table of Thermal Shield Cooling System Relief Valve Settings (5.4-2)	3
	T3	Table of Thermal Shield Cooling System Alarm Settings (5.4-3)	3
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	2.1	Procedure for System Startup Following Normal or Extended Reactor Shutdown	4-8
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	3.1	Routine Shutdown Procedure	11
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5.0	Procedure for Two Pump Operation		14-15

5.4 Thermal Shield Cooling System Operating Procedures

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	7.1	Prestartup Check Procedure	16-17
	7.2	System Startup Procedure	17
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9.0	Normal System Makeup Procedure		18
10.0	Procedure for Gross Makeup		18-19
11.0	Procedure for Filling Makeup Tank with Domestic Water		19

5.4 Thermal Shield Cooling System Operating Procedures

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Part B	Thermal Shield Cooling System Valve Line-up Checklist	22-24
F1	Thermal Shield Coolant Conductivity vs Cooler Outlet Temperature Curve (5.4-1)	25
F2	Thermal Shield Cleanup Loop (5.4-2)	26
-	References	27

5.4 Thermal Shield Cooling System Operating Procedures

1.0 System Operating Restrictions

1.1 System Setback Setting - In accordance with the "Setback, Scram, Seismic, Depressurization, Low-Low and Low-Low-Low Action Settings Table" (Ref. 1).

1.2 System Operating Parameters - In accordance with the "Table of Thermal Shield Cooling System Limiting Parameters" (Table 5.4-1).

1.3 System Relief Valve Settings - In accordance with the "Table of Thermal Shield Cooling System Relief Valve Settings" (Table 5.4-2).

1.4 System Alarm Settings - In accordance with the "Table of Thermal Shield Cooling System Alarm Settings" (Table 5.4-3).

1.5 System Startup and Shutdown Procedures - Whenever the Thermal Shield Cooling System is started up or shut down, the appropriate checklist portion of the system startup (Section 2.1 or 2.2) or shutdown (Section 3.1 or 3.2) procedures shall be completed.

1.6 pH Control and Cleanup Loop Maintenance Procedures - Procedures to control pH or perform maintenance on the cleanup loop are found in Operations files section 18.

TABLE OF THERMAL SHIELD COOLING SYSTEM LIMITING PARAMETERS

Table 5.4-1

Exceptions	Operating Variable	Mode of Reactor Operation	Reactor Operating Limit	System Operating Limit
1	Minimum Lower Thermal Shield Coolant Flow	All	600 gpm	----
1	Minimum Upper Thermal Shield Coolant Flow	All	60 gpm	----
1	Minimum Cooling Coil Flow	All	20 gpm	----
None	Maximum Cooler Primary Flow	All	----	840 gpm
None	Maximum Diff. Press. Across Cleanup Filters	All	----	35 psid
None	Maximum Cooler Primary Pressure	All	----	75 psig
None	Maximum Cooling Circuit Outlet Temperature	All	60°C	----
None	Maximum Expansion Tank Liquid Level	All	19 inches	----
None	Minimum Expansion Tank Liquid Level	All	1 inch	----
None	Maximum Dissolved Oxygen Concentration	All	—	5 ppb
None	Minimum System Makeup Water Resistivity	All	—	0.2 megohm-cm

1 Exceptions to these limits are permitted for 15 second outages during switching of pumps. (YP)

TABLE OF THERMAL SHIELD COOLING SYSTEM RELIEF VALVE SETTINGS

Table 5.4-2

The following relief valve settings shall not be changed without Group Leader Authorization.

Relief Valve Designation	Setting
Thermal Shield Cooling System Pressure Relief Valve SV201 (Overpressure Protection)	2 psig
Thermal Shield Cooling System Pressure Relief Valve SV201 (Underpressure Protection)	- 0.125 psig or 14.575 psia

TABLE OF THERMAL SHIELD COOLING SYSTEM ALARM SETTINGS

Table 5.4-3

The following alarm settings shall not be changed without Group Leader Authorization.

Alarm Condition	Instrument Circuit	Alarm Settings
Low Coolant Flow	Lower Thermal Shield, FRa201	650 gpm
High Coolant Temperature	Thermal Shield Cooling Circuits Outlet, TRa6	55° C
High H_20 Level	Tank FA201, LIa201	19 in.
Low H_2O Level	Tank FA201, LIa201	7 in.

2.0 Thermal Shield Cooling System Startup Procedure

2.1 Procedure for System Startup following Normal or Extended Reactor Shutdown

Note: Completion of this procedure is required prior to all Thermal Shield Cooling System startups other than startups following short duration system shutdown (covered in Section 2.2). This procedure shall be completed to satisfy the requirements of the HFBR Startup Checklist.

Initials

2.1.1 Perform appropriate parts of the Thermal Shield Cooling System Valve Line-up Checklist.

2.1.1.1 Part A System Line-up checklist completed____

2.1.1.2 Part B System Line-up checklist not required____

2.1.1.3 Per Group Leader or Shift Supervisor instructions, Part B System Line-up checklist completed (parts:__________)_____ ______

2.1.2 Check the following electrical breakers are ON:

2.1.2.1 15KVA Instrument transformer breaker on EMCC___

Note: If pumps GA201A or B breakers are OFF, perform step 2.1.8 prior to closing breaker.

2.1.2.2 GA201A Thermal shield pump on MCC No. 1___

2.1.2.3 GA201B Thermal shield pump on MCC No. 1___

2.1.2.4 Power Recep. Cir. F Thermal Shield Expansion Tank Circulating Pump on MCC No. 2___ ______

2.1.3 Check that Building Compressed Air system is operating.
Compressor GB301____ (A, B, or C) on line
PA301____ (80-110) psi ______

Initials

2.1.4 Check that the level in the Thermal Shield Expansion Tank FA201 is 11 to 15 inches.
LIa201 level____ (11-15) inches ______

Note: If the level in FA201 is not within limits, refer to 10.0, 11.0 of this OPM section, as appropriate, to fill the system or refer to Operations files section 18 for draining.

2.1.5 Establish nitrogen purge rate of 100 cm^3/min. at 5 psig to sparge Thermal Shield Expansion Tank FA201. ______

2.1.6 One Reactor Operator stationed at the controls. ______

2.1.7 One Reactor Operator stationed on Equipment Level to monitor system startup. ______

2.1.8 Check or place console selector switches for pumps GA201A and GA201B in OFF.
GA201A OFF____
GA201B OFF____ ______

2.1.9 Place local disconnect switches for pumps GA201A and GA201B to ON.
GA201A ON____
GA201B ON____ ______

Note: If the system was filled prior to startup, air trapped in the system may cause expansion tank level to drop. Fill the system in accordance with sections 10.0 or 11.0 as necessary, and repeat startup procedure to ensure the limits of step 2.1.4 are satisfied.

2.1.10 Place console selector switch for the pump selected as "standby" to AUTO.
Pump GA201____(A or B) in AUTO ______

Initials

2.1.11 Check the flow rates in the system and make necessary valve adjustments as follows:

Note: Adjusting the flow rate in any of the four loops may cause flow rates to change in other loops. Readjust valves WC6, WC7, WC23, WC15, WC3, and WC4 as necessary to establish proper flow rates in the four system loops.

2.1.11.1 FRa201 flow____(690-715) gpm (adjust WC23)
2.1.11.2 FI202 flow____(100-110) gpm (adjust WC7)
2.1.11.3 FI207 flow____(28-32) gpm (adjust WC6)
2.1.11.4 Cleanup flow____(2-5) gpm (adjust WC15)
2.1.11.5 GA201___(A or B) differential pressure_____(19-22) psid (adjust WC3 for A or WC4 for B) ______

2.1.12 Check system alarms and setback alarms clear.

2.1.12.1 System Alarms Clear
- Flow Low Thermal Shield, FRa201____
- Level Hi-Lo Thermal Shield Exp. Tank, LIa201____

______

2.1.12.2 Setback Alarms Clear
- Flow Low Thermal Shield, FRa201____

and either of the following:
- Pump A OFF, Thermal Shield, GA201A Bkr____
- Pump B OFF, Thermal Shield, GA201B Bkr____

______

2.1.13 Place the console selector switch for the "standby" pump to OFF.
Pump GA201____(A or B) OFF ______

2.1.14 Place the console selector switch for the "run" pump to HAND.
Pump GA201____(A or B) in HAND ______

2.1.15 Place the console selector switch for the "standby" pump to AUTO.

Initials

Pump GA201____(A or B) in AUTO ______

2.1.16 Recheck the flow rates with the "run" pump operating. If any flow rates are out of range, recheck the appropriate valve line-up and/or throttle valve positions as necessary.

2.1.16.1 FRa201 flow____(690-715) gpm (adjust WC23)
2.1.16.2 FI202 flow____ (100-110) gpm (adjust WC7)
2.1.16.3 FI207 flow____ (28-32) gpm (adjust WC6)
2.1.16.4 Cleanup flow ____(2-5) gpm (adjust WC15)
2.1.16.5 GA201___(A or B) differential pressure_____(19-22) psid (adjust WC3 for A or WC4 for B) ______

__Note:__ If valves WC6, WC7, WC15 or WC23 had to be readjusted in 2.1.15 above, turn off pumps GA201A and B by placing console selector switches to OFF (switch standby pump OFF first) and repeat steps 2.1.10 to 2.1.15.

2.1.17 Check system alarms and setback alarms clear.
2.1.17.1 System Alarms Clear
- Flow Low Thermal Shield, FRa201____
- Level Hi-Lo Thermal Shield Exp. Tank, LIa201____

______

2.1.17.2 Setback Alarms Clear
- Flow Low Thermal Shield, FRa201____

__and either__ of the following:
- Pump A OFF, Thermal Shield, GA201A Bkr____
- Pump B OFF, Thermal Shield, GA201B Bkr____ ______

2.1.18 Start Thermal Shield Expansion Tank Circulating Pump. ______

2.1.19 Start the Dissolved Oxygen Analyzer. ______

Initials

2.1.20 Throttle balance valve WC32 to obtain 2.5 to 3.5 gpm. ______

2.1.21 Establish secondary cooling water flow through heat exchanger EA201 as necessary. ______

Comments____

____

____

Shift Supervisor______________________ Date __________

2.2 Procedure for System Startup Following Short Duration System Shutdown

Note: Completion of this procedure is applicable only to situations where the Thermal Shield Cooling System status has remained unchanged since the previous normal Thermal Shield Cooling System operation. This procedure does not apply to startup of the Thermal Shield Cooling System for the purpose of normal reactor startup (refer to Section 2.1 for these startups).

Initials

2.2.1 Check that the level in the Thermal Shield Expansion Tank FA201 is 11 to 15 inches.
LIa201 level____ (11-15) inches ______

2.2.2 One Reactor Operator stationed at the controls. ______

2.2.3 One Reactor Operator stationed on the Equipment Level to monitor system startup. ______

2.2.4 Place or check console selector switches for pumps GA201A and GA201B in OFF.
GA201A OFF____
GA201B OFF____ ______

2.2.5 Check local disconnect switches for pumps GA201A and GA201B are ON.
GA201A ON____
GA201B ON____ ______

2.2.6 Place the console selector switch for the "run" pump to HAND.
GA201____(A or B) in HAND ______

2.2.7 Place the console selector switch for the "standby" pump to AUTO.
GA201____ (A or B) in AUTO ______

Initials

2.2.8 Check the flow rates in the system and make necessary valve adjustments as follows:

2.2.8.1 FRA201 flow ____(690-715) gpm (adjust WC23)
2.2.8.2 FI202 flow____ (100-110) gpm (adjust WC7)
2.2.8.3 FI207 flow____(28-32) gpm (adjust WC6)
2.2.8.4 Cleanup flow____(2-5) gpm (adjust WC15)
2.2.8.5 GA201___ (A or B) differential pressure_____(19-22) psid (adjust WC3 for A or WC4 for B) ______

2.2.9. Check system alarms and setback alarms clear.

2.2.9.1 System Alarms Clear
- Flow Low Thermal Shield, FRa201____
- Level Hi-Lo Thermal Shield Exp. Tank, LIa201____

______

2.2.9.2 Setback Alarms Clear
- Flow Low Thermal Shield, FRa201____

and either of the following:
- Pump A OFF, Thermal Shield, GA201A Bkr____
- Pump B OFF, Thermal Shield, GA201B Bkr____ ______

2.2.10 Start Thermal Shield Expansion Tank Circulation Pump. ______

2.2.11 Throttle balance valve WC32 to obtain 2.5 to 3.5 gpm. ______

2.2.12 Start the Dissolved Oxygen Analyzer. ______

Comments____
____
____

Shift Supervisor______________________ Date __________

3.0 Thermal Shield Cooling System Shutdown Procedures

3.1 **Routine Shutdown Procedure** - This procedure is to be used for system shutdown system where the status of the system is expected to remain unchanged for the duration of the system shutdown.

Note: Shutting down the Thermal Shield Cooling System while the reactor is operating will initiate a setback.

Initials

3.1.1 Place the console selector switch for the "standby" pump to OFF.
Pump GA201______(A or B) OFF ______

3.1.2 Place the console selector switch for the "run" pump to OFF.
Pump GA201______(A or B) OFF ______

3.1.3 Shut down the Thermal Shield Expansion Tank circulating pump. ______

3.1.4 Shut down Dissolved Oxygen Analyzer. ______

Comments____
____
____

Shift Supervisor______________________ Date __________

3.2 **Extended Shutdown Procedure** - This procedure is to be used for system shutdown for extended periods where changes to the system status are likely to be made.

Note: Shutting down the Thermal Shield Cooling System while the reactor is operating will initiate a setback.

Initials

3.2.1 Place the console selector switch for the "standby" pump to OFF.
Pump GA201______(A or B) OFF ______

3.2.2 Place the console selector switch for the "run" pump to OFF.
Pump GA201______(A or B) OFF ______

3.2.3 Shut down the Thermal Shield Expansion Tank circulating pump. ______

3.2.4 Place pumps GA201A and GA201B local disconnect switches to OFF.
GA201A OFF____
GA201B OFF____ ______

3.2.5 Close pump GA201A and GA201B suction and discharge valves.
WC1 Closed____
WC2 Closed____
WC3 Closed____
WC4 Closed____ ______

3.2.6 Shut down the Thermal Shield clean-up system by closing the inlet and outlet valves.
WC43 Closed____
WC14 Closed____ ______

3.2.7 Shut off the secondary cooling water to Thermal Shield Cooler EA201 by closing the inlet and outlet valves.
WS4 Closed____
WR4 Closed____ ______

Initials

3.2.8 Open the breakers on MCC No. 1 for pumps GA201A and GA201B.
GA201A Breaker OFF____
GA201B Breaker OFF____ ________

3.2.9 Open breaker on MCC No. 2 for Expansion Tank Circulating Pump.
Power Recep. Cir. F. Thermal Shield Expansion Tank Circulating
Pump OFF____ ________

3.2.10 Shut down Dissolved Oxygen Analyzer. ________

Comments____
____
____

Shift Supervisor______________________ Date __________

4.0 Procedure for Switching Pumps with One Pump Operating

Note: Improper switching of pumps during reactor operation may result in reactor setback action.

4.1 Note the flow rates on FRa201, FIa202 and FI207 before performing the switching operation.

4.2 Start the "standby" pump by placing its console selector switch to HAND.

4.3 Check that there has been an increase in flow in the three legs of the system. With both pumps operating, the following flows should be indicated: FRa201 approximately 940 gpm, FI202 approximately 144 gpm, FI207 approximately 42 gpm.

4.4 If the pump which has been shut down is in operating condition, place it in "standby" by placing the console selector switch to AUTO. If it shouldn't be operated, place the local disconnect switch to OFF, open and tag out the pump breaker on MCC No. 1, and tag out the pump's console selector switch in OFF, and remove and tag fuse from setback circuit.

4.5 Make minor adjustments to valves WC6, WC7, WC15 and WC23 as necessary to provide the desired flows and make minor adjustments to valves WC3 or WC4 to provide desired pump differential pressures.

5.0 **Procedure for Two Pump Operation** - Two pump operation is necessary to clear the setback bus when flow channel FRa201 is out of service and has been tripped out in an approved manner. This procedure may only be used when it is known that the system valves have not been adjusted since FRa201 last read correctly.

5.1 Start the "run" pump if it is not operating. Console selector switch must be in the HAND position.

5.2 Note the flow rates on FI202 and FI207 before starting the "standby" pump.

5.3 Start the "standby" pump by placing its console selector switch in HAND.

5.4 Check that there has been an increase in flow on FI202 and FI207. With both pumps operating, the following flows should be indicated: FI202 approximately 144 gpm and FI207 approximately 42 gpm.

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5.5 Place a hold tag on Lower Thermal Shield Supply valve, WC23, to prevent it from being throttled until FRa201 flow channel is back in service.

6.0 Thermal Shield Cooling System Normal Operating Instructions

6.1 Modes of Thermal Shield Cleanup Loop Operation

6.1.1 Normal Mode of Operation - The normal mode of thermal shield cleanup loop operation is with bed No. 1, a LiOH mixed bed, in series with bed No. 2, the OH anion bed; and with bed No. 3, a LiOH mixed bed, in parallel with beds No. 1 and No. 2.

6.1.2 Reducing pH Mode of Operation - This mode of operation requires replacing the LiOH resins in bed No. 3 with cation or mixed resins and establishing flow through this bed until the pH is reduced the desired amount. Specific instructions will be provided by the Water Chemist for this mode.

6.2 Thermal Shield Cleanup Loop Normal Operating Values

6.2.1 Cleanup Loop Flow: 2 to 5 gpm.

6.2.2 LiOH mixed bed resins should be changed when less than 50% of the gross beta-gamma activity of the water entering the loop is removed by the bed, as determined by the Water Chemistry Group.

6.2.3 OH anion bed resin should be changed when the chloride content of water exceeds 100 ppb, as determined by the Water Chemistry Group.

6.3 Expansion Tank Circulating Loop Normal Operating Values

6.3.1 Circulating Loop Flow: 2.5 to 3.5 gpm.

6.3.2 Expansion Tank Nitrogen Purge Rate: 100 cm^3/min at 5 psig supply pressure.

6.3.3 Circulating Loop Coolant pH: 10.0 to 11.0 as determined from "Thermal Shield Coolant Conductivity vs. Cooler Outlet Temperature Curve" (Figure 5.4-1).

7.0 **Procedure for Putting Thermal Shield Cleanup Loop in Operation** - This procedure lines up bed No. 1, a LiOH mixed bed, in series with bed No. 2, the OH anion bed; and with bed No. 3, a LiOH mixed bed, in parallel with beds No. 1 and No. 2.

7.1 Prestartup Check Procedure

7.1.1 Check that the Equipment Level Motor Control Center (MCC No. 1) is energized and close the following breaker:

7.1.1.1 Thermal Shield Cleanup System Booster Pump and Fuel Cutoff Saw Hoist.

7.1.2 Check that the following valves are closed, and if not, close same:

7.1.2.1 WC44 and WC45 Spare Connection.

7.1.2.2 WC17, WC18, and WC50 Bed Nos. 1, 2, and 3 Vents.

7.1.2.3 WC19, WC21, and WC22 Inlet and Outlet Sample and other sample valves and pressure gauge vent valves.

7.1.2.4 DD45, DD46, and DD48 Bed Nos. 1, 2, and 3 Drains.

7.1.2.5 DD47 Drain to "D" Waste.

7.1.2.6 WC15 Booster Pump Bypass, if booster pump is to be used.

7.1.3 Check that the following valves are open, and if not, open same:

7.1.3.1 WC46 Supply to Cleanup System Valve.

7.1.3.2 WC13 Inlet to Cleanup System.

7.1.3.3 WC16 Booster Pump Discharge.

7.1.3.4 WC15 Booster Pump Bypass, if booster pump is not to be used.

7.1.3.5 WC20 Cleanup System Inlet.

7.1.3.6 WC47 Bed No. 1 Inlet.

7.1.3.7 WC49 Bed No. 3 Inlet.

7.1.3.8 WC48 Bed No. 2 Inlet.

7.1.3.9 WC52 Bed No. 2 Outlet.

7.1.3.10 WC51 Bed No. 3 Outlet.

7.2 System Startup Procedure

7.2.1 Open Supply to Cleanup System Valve WC43 and Outlet from Cleanup System Valve WC14.

7.2.2 Start cleanup loop booster pump if necessary.

7.2.3 Adjust flow through loop to 2 to 5 gpm by throttling Booster Pump Discharge Valve WC16. If booster pump is not used, shut WC16 and throttle WC15 to obtain 2 to 5 gpm.

8.0 Procedure for Removing the Thermal Shield Cleanup Loop from Operation

8.1 If the cleanup loop booster pump is operating, shut it down.

8.2 Close Supply to Cleanup System Valve WC43 and Outlet from Cleanup System Valve WC14.

9.0 Normal System Makeup Procedure - One inch of level in the thermal shield expansion tank represents 1.3 gallons.

9.1 Adjust nitrogen purge to makeup tank to 20,000 cm^3/min for two hours prior to adding makeup.

9.2 With expansion tank circulating loop in operation, open Suction from Makeup Tank Valve WC26. Suction from Thermal Shield Valve WC24 may be throttled to increase the rate of makeup. Stop makeup addition if dissolved oxygen analyzer indicates 5 ppb oxygen. Continue nitrogen purging of makeup tank until dissolved oxygen is less than 5 ppb.

9.3 When addition of makeup water is completed, FA201 level 11 to 15 inches, open valve WC24, and close valve WC26.

10.0 Procedure for Gross Makeup - This procedure should only be used when large quantities of makeup water, which cannot be supplied using the normal makeup procedure, e.g., following maintenance that required extensive draining of system. When makeup is added in this mannner, LiOH solution should be slug fed in accordance with "Procedure to Increase System pH" (see Operations file section 18.0).

10.1 Check that Expansion Tank Vent Valve WC8 is open.

10.2 Makeup water should be available from Auxiliary Water Purification System BG201 in accordance with "Auxiliary Water Purification System Procedures."

10.3 Close Supply from BG201 to Canal Valve TW19.

10.4 Open Supply from BG201 to Thermal Shield System Valve TW20 and isolation valve TW20A. Add makeup until the level in the expansion tank is 11 to 15 inches.

10.5 Close Supply from BG201 to Thermal Shield System Valve TW20 and isolation valve TW20A. These valves must be closed tight to prevent the system water from draining into the canal.

10.6 Open Supply from BG201 to Canal Valve TW19, if it was open before making up water.

11.0 Procedure for Filling Makeup Tank with Domestic Water

Note: Exceeding 15-20 gph rate reduces the effectiveness of the mixed resins.

11.1 Open Makeup Water Supply Valve WC41.

11.2 Fill makeup tank through mixed resin cartridges at 15-20 gph by opening Domestic Water Makeup Supply Valve DW12.

11.3 When makeup tank is filled, close Domestic Water Makeup Valve DW12 and Makeup Water Supply Valve WC41.

THERMAL SHIELD COOLING SYSTEM VALVE LINE-UP CHECKLIST

Page 1 of 2

Part A: This part must be completed prior to any Thermal Shield Cooling System startup following a Normal Reactor Shutdown or an Extended Reactor Shutdown, in order to satisfy the requirements of the HFBR Startup Checklist.

1. On the Equipment Level open or check open the following valves:

		Valve Position	Initials
a.	WC3 Pump GA201A discharge	______	______
b.	WC4 Pump GA201B discharge	______	______
c.	WC1 Pump GA201A suction	______	______
d.	WC2 Pump GA201B suction	______	______
e.	WC23 Lower Thermal Shield Supply	______	______
f.	WC6 Supply to Cooling Coils	______	______
g.	WC7 Supply to Upper Thermal Shield	______	______
h.	WC5 Cooler EA201 Bypass	______	______
i.	WC43 Supply to Cleanup System	______	______
j.	WC14 Outlet from Cleanup System	______	______

2. On the Equipment Level close or check closed the following valves:

		Valve Position	Initials
a.	DD49 GA201A Check Valve Drain	______	______
b.	DD8 Pump GA201A drain	______	______
c.	DD9 Pump GA201B drain	______	______
d.	DD16 Thermal Shield Cavity Drain and Purge	______	______

THERMAL SHIELD COOLING SYSTEM VALVE LINE-UP CHECKLIST

Part A (Cont'd)

Page 2 of 2

		Valve Position	Initials
e.	DD10 Cooler EA201 drain	______	______
f.	DD47 Drain to D waste	______	______
g.	DD48 Bed No. 3 drain	______	______
h.	DD46 Bed No. 2 drain	______	______
i.	DD45 Bed No. 1 drain	______	______
j.	DD50 GA201B check valve drain	______	______
k.	DD11A Secondary Cooling Water drain	______	______
l.	DD11 Secondary Cooling Water drain	______	______

Comments____
____
____

Shift Supervisor________________________ Date ___________

THERMAL SHIELD COOLING SYSTEM VALVE LINE-UP CHECKLIST

Page 1 of 3

Part B: Specified parts must be completed in addition to Part A prior to any Thermal Shield Cooling System Startup as directed by the Group Leader or Shift Supervisor, in order to satisfy the requirements of the HFBR Startup Checklist.

1. On the Equipment Level open or check open the following valves:

		Valve Position	Initials
a.	WC46 Supply to cleanup system	______	______
b.	WC52 Bed No. 2 Outlet	______	______
c.	WC48 Bed No. 2 Inlet	______	______
d.	WC47 Bed No. 1 Inlet	______	______
e.	WC20 Cleanup System Inlet	______	______
f.	WC15 Booster Pump Bypass	______	______

2. On the Equipment Level close or check closed the following valves:

		Valve Position	Initials
a.	WC9 Sample valve	______	______
b.	WC10 Sample valve	______	______
c.	WC44 pH meter inlet	______	______
d.	WC22 Outlet sample	______	______
e.	WC21 Outlet sample	______	______
f.	WC50 Bed No. 3 vent	______	______
g.	WC49 Bed No. 3 inlet	______	______

THERMAL SHIELD COOLING SYSTEM VALVE LINE-UP CHECKLIST

Part B (Cont'd)

Page 2 of 3

		Valve Position	Initials
h.	WC51 Bed No. 3 outlet	______	______
i.	WC18 Bed No. 2 vent	______	______
j.	WC17 Bed No. 1 vent	______	______
k.	WC19 Inlet sample	______	______
l.	WC16 Booster pump discharge	______	______
m.	WC13 Inlet to cleanup system	______	______
n.	WC45 pH meter outlet	______	______

3. On the Operations Level, outside the east wall of the Greenhouse, open or check open the following valves:

		Valve Position	Initials
*a.	WC8 Vent Valve	______	______
b.	WC28 Flow meter inlet	______	______
c.	WC29 Flow meter outlet	______	______
d.	WC24 Suction from thermal shield	______	______
e.	WC53 Oxygen Analyzer Sample Water Supply	______	______
f.	WC54 Sample conditioner discharge	______	______

*in the Greenhouse

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THERMAL SHIELD COOLING SYSTEM VALVE LINE-UP CHECKLIST

Part B (Cont'd)

Page 3 of 3

4. On the Operations Level, outside the east wall of the Greenhouse, close or check closed the following valves:

		Valve Position	Initials
*a.	WC11 Off gas sample valve		
*b.	WC12 Off gas sample valve		
c.	WC39 LiOH supply from LiOH Tank		
d.	WC41 Make up Water Supply		
e.	WC36 LiOH flow meter inlet		
f.	WC38 LiOH flow meter bypass		
g.	WC37 LiOH flow meter outlet		
h.	WC40 LiOH tank vent		
i.	WC42 LiOH supply to FA201		
j.	WC26 Suction from makeup tank		
k.	WC30 Flow meter bypass		
l.	WC25 Suction from FA201		
m.	WC34 O_2 analyzer to makeup tank		
n.	WC35 O_2 analyzer to FA201		

*in the Greenhouse

Comments____

____

____

Shift Supervisor_________________________ Date ___________

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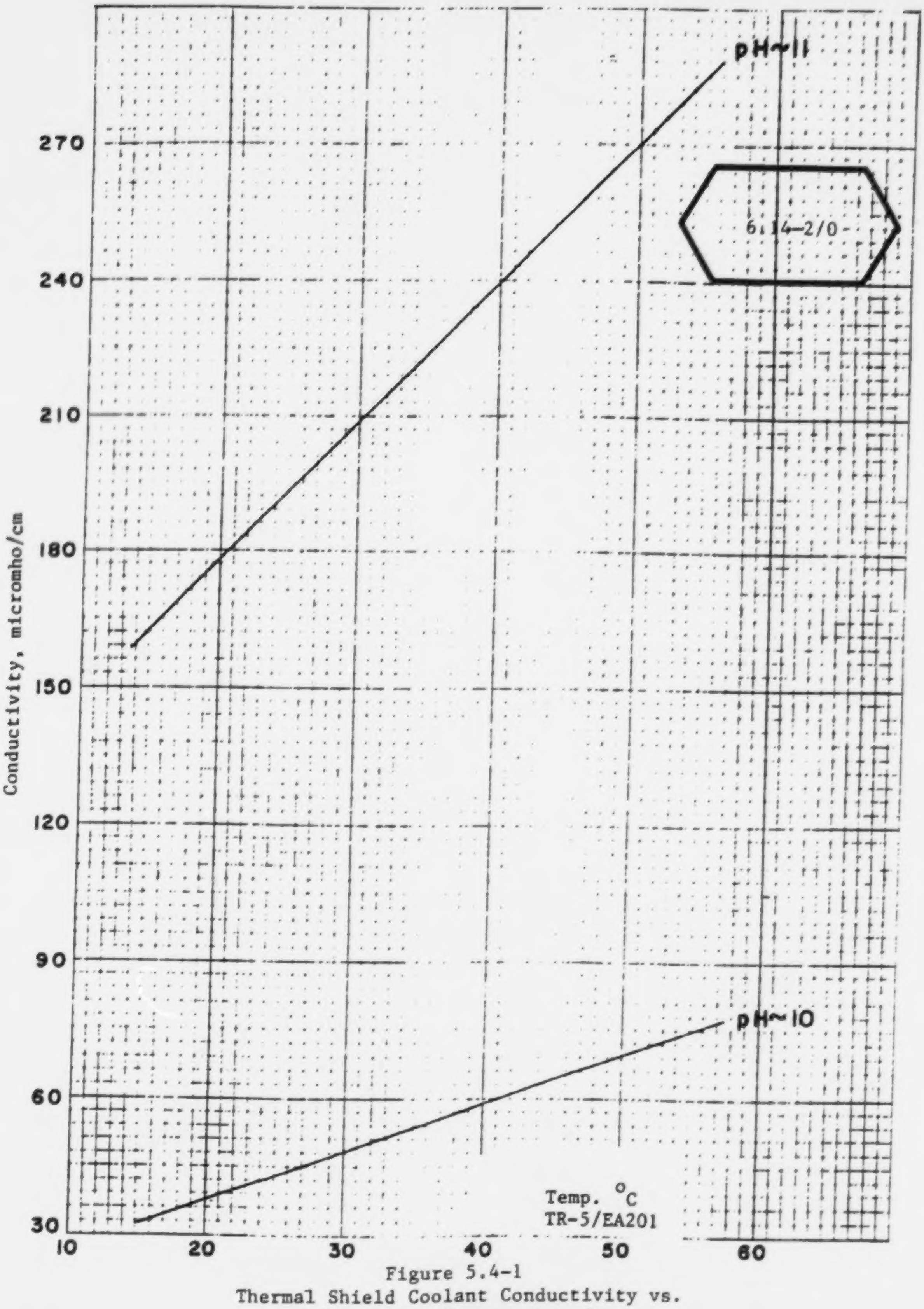

Figure 5.4-1
Thermal Shield Coolant Conductivity vs.
Cooler Outlet Temperature Curve

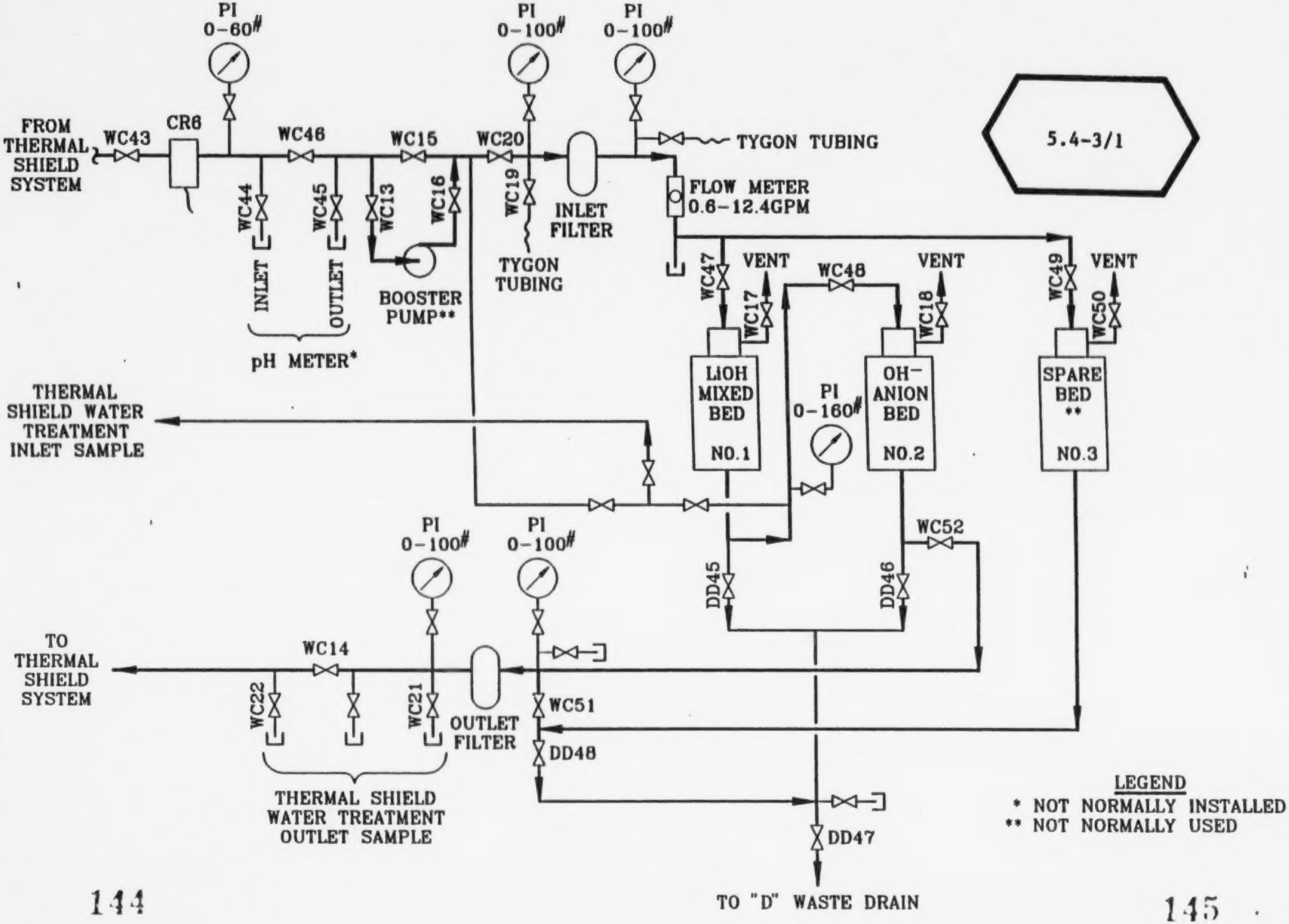
PI
0-60#
PI
0-100#
PI
0-100#
5.4-3/1
FROM THERMAL SHIELD SYSTEM
WC43
CR6
WC46
WC15
WC20
TYGON TUBING
WC44
WC45
WC13
WC16
WC19
INLET FILTER
FLOW METER 0.6-12.4GPM
INLET
OUTLET
pH METER*
BOOSTER PUMP**
TYGON TUBING
WC47
VENT
WC48
VENT
WC49
VENT
WC17
WC18
WC50
LIOH MIXED BED NO.1
OH- ANION BED NO.2
SPARE BED ** NO.3
PI
0-160#
THERMAL SHIELD WATER TREATMENT INLET SAMPLE
WC52
DD45
DD46
PI
0-100#
PI
0-100#
TO THERMAL SHIELD SYSTEM
WC14
WC22
WC21
OUTLET FILTER
WC51
DD48
THERMAL SHIELD WATER TREATMENT OUTLET SAMPLE
DD47
TO "D" WASTE DRAIN
LEGEND
* NOT NORMALLY INSTALLED
** NOT NORMALLY USED

Figure 5.4-2
Thermal Shield Cleanup Loop

References

[1] Table 2.1-1 of this manual

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APPENDIX B

HFBR CURRICULUM MEETING AGENDA AND MINUTES

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

DATE: November 15, 1990

TO: HFBR Training Curriculum Review Committee Members

FROM: R. C. McNair

SUBJ: Restart and Continuing Training

A Curriculum Review Committee meeting is scheduled for November 19 at 10:00am in the HFBR lobby conference room.

The following topics will be presented:

- Quarterly Training
- Restart Training
- General Employee Training
- Operator and Supervisor Qualification Guides
- Task Master
- Accreditation

If you are not able to attend, please assign a designee. If you have any questions regarding the agenda, please contact me at ext. 2270.

cc: M. Brooks
Accreditation File A-7.9

Committee Members
L. Junker
A. Queirolo
R. Reyer
C. Scarlett
W. Brynda
P. Tichler
B. Murray
O. Jacobi
N. Holden
V. Lettieri
L. Engel

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

DATE: December 5, 1990

TO: Distribution

FROM: R. McNair

SUBJ: Minutes of HFBR Training Curriculum Review Committee Meeting 11/19/90

Attached is a copy of the minutes of the subject meeting. Any corrections to the minutes will be stated in the minutes of the next meeting.

Distribution:
Brooks, M.
Barkwill, J.
Queirolo, A.
Reyer, R.
Scarlett, C.
Tichler, P.
Murray, B.
Jacobi, O.
Holden, N.
Lettieri, V.
Engel, L.
Junker, L.
Tanguay, J.
Lein, B.
Scott, J.
Karol, R.
Malachowsky, R.
McNair, R.

Attendees
Junker, L.
Tanguay, J.
Holden, N.
Lein, B.
Scott, J.
Murray, B.
Karol, R.
Malachowsky, R.
Barkwill, J.
Reyer, R.
Lettieri, V.
McNair, R.

Topic: Revised Reactor Operator/Shift Supervisor Qualification Guide Checklist - R. McNair

The following items were discussed:

- Philosophy - Must complete reactor operator checklist prior to starting a shift supervisor checklist
- The upgraded qualification guide checklist standardize the skills, knowledge, and task required for certification.
- The upgraded qualification guide checklist standardize the evaluation tool used to evaluate skills, knowledge, and tasks required for certification
- The shift supervisor checklist will only include additonal tasks required beyond the reactor operator position
- Use of table of contents and how they are linked to the PDM, OPM, and Tickler Cards
- Once a trainee completes Section "A" (all PDM sections) the trainee is required to take a written comprehensive exam prior to task performance
- Performance guidance, instruction for implementation, and evaluation sign off requirements were discussed.

At the conclusion of this topic the following requests were made:

Operations will identify the tickler cards that should be performed for reactor operator and shift supervisor positions.

Training will review implementation of the qualification guide checklist with the shift supervisors.

Topic: Task Master - R. McNair

The committee was informed that the Training Group evaluated and would purchase the software from General Physics Corp. The program will help in the accreditation effort to link task, objectives, exam question, training material, etc., in the accreditation effort.

APPENDIX C

FOURTH QUARTER HFBR TRAINING SCHEDULE

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

DATE: November 13, 1990

TO: Distribution

FROM: J. Scott

SUBJ: Fourth Quarter '90 HFBR Training

Enclosed is the schedule for fourth quarter '90 training. There will be two days of training on the subjects listed below. The first day will cover the six tasks listed below. The second day will encompass two emergency shift drills.

	TASK	INSTRUCTOR
1.	Operator and Supervisor Revised Certification Checklists	R. McNair
2.	RD Reportable Occurrence Reporting System	T. Stephenson
3.	New OPM Process Procedures Format and Use	S. Nappi
4.	Fire Protection System Modification	D. Ports
5.	Yellow Page Emergency Procedures Revisions	B. Lein
6.	CNF Modifications	J. Scott

Training sessions will begin promptly at **0830** in the HFBR Lobby Conference Room on the dates scheduled.

Distribution:

Abel, P.
Barkwill, J.
Bingham, D.
Colson, O.
Daniels, T.
Davis, M.
Diaz, C.
Diaz, R.
Duggan, J.
Evers, L.
Frei, H.
Harris, A.
Hudson, R.
Jayne, G.
Kelso, P.
Lang, P.
Stuart, M.
McNair, R.
Nappi, S.
Nelson, J.
Niewiarowicz, M.
Pankowski, M.
Ports, D.
Powers, T.
Queirolo, A.
Rooks, R.
Sauerbrun, F.
Sierra, E.
Somma, A.
Stonebridge, D.
Tache, D.
Baldwin, M.
Bloom, J.
Zukas, G.

1990 FOURTH QUARTER TRAINING SCHEDULE
HFBR SUPERVISORS AND OPERATORS

Name	Class Date	Designated Relief	Exam Date
Bergoffen, R. Sierra, E. Hudson, R. Davis, M. Diaz, R. Sauerbrun, F. Baldwin, M. Daniels, T. Kelso, P.	Nov. 28-29	Nappi, S. Rooks, R. Abel, P.	December 3, 1990
Harris, A. Colson, O. Evers, L. Duggan, J. McNair, R. Bloom, J. Stonebridge, J. Barkwill, J.	Dec. 5-6	Lang, P. Rooks, R. Abel, P.	December 10, 1990
Diaz, C. Nelson, J. Tache', R. Abel, P. Somma, L. Zukas, G. Nappi, S. Lang, P. Queirolo, A.	Dec. 12-13	Davis, M. Rooks, R. Duggan, J.	December 17, 1990
Frei, H. Jayne, G. Bingham, D. Stuart, M. Pankowski, M. Scott, J. Ports, D. Powers, T. Rooks, R.	Dec. 19-20	McNair, R. Abel, P. Duggan, J.	December 26, 1990

Classes will be held in Building 750, Lobby Conference Room beginning promptly at 0830 on November 28 & 29, December 5 & 6, 12 & 13, 19 and 20.

APPENDIX D

PROJECT PLAN

```
                1/90                                                       12/13/90
---------------|----------------------------------------------------------------|----
               |   80h                                                          |
ANALYSIS       |0--------0                                                      |
               |       65h                                                      |
DESIGN         |     0------0                                                   |
               |                             1261h                              |
DEVELOPMENT    |          0-----------------------------------------------0     |
               |                          1440h                                 |
IMPLEMENTATION |                    0------------------0                        0----
               |                                                                |
               |            18h                     18h                       16h
EVALUATION     |          0-----0                 0-----0                    0----0
               |                                                                |
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APPENDIX E

HFBR PBT QUALIFICATION GUIDE/CHECKLIST

AUTHORIZATION AND CLARIFICATION GUIDANCE

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

DATE: December 13, 1990

TO: HFBR Supervisors/Trainees

FROM: R. Reyer

SUBJ: HFBR Operator Qualification Guide Checklist Revisions

Attached is a copy of the subject document for your information and use. It is the end product of reformatting and expanding the previous checklist to include a better definition of the skills, knowledge and tasks involved in the certification of the reactor operator position. It is being issued for use at this time as part of a pilot program in lieu of the existing checklist. The new format is a prototype of that which will be used as a record of the training accomplished as part of the accreditation effort. As it is a prototype, any comments you have regarding typos, omissions and needed clarifications would be greatly appreciated. We have included a form and instructions for its use to formalize any comments you may have.

12/13/90
Al Queirolo
HFBR Operations Group Leader

R. Reyer
Ron Reyer
Training and Procedures
Group Manager

CLARIFICATION GUIDANCE

The upgraded qualification guide standardized the skills, knowledge, and tasks required to be performed by the reactor operator trainees. In addition, the evaluation method used by the shift supervisor to evaluate trainee performance was also standardized. The development of this performance based training qualification guide was prompted by the Training Accreditation Program required to be implemented by the Department of Energy. This phase of the qualification guide and soon to follow lesson plans, objectives, and upgraded plant description manuals are part of the planned accreditation process.

This qualification guide should be implemented in so far as practical. In areas where documentation is difficult to obtain from the Plant Description Manual (PDM), Operating Procedures Manual (OPM), or other existing operational files, the trainee should request the shift supervisor for assistance. If documentation can not be found to support the skill, knowledge or task required, a request for assistance should be made through the Training Group. A "REQUEST FOR CLARIFICATION" form should be filled out by the shift supervisor and submitted to the Training Group. Please forward all requests to R. McNair, Accreditation Coordinator.

Responses will be sent back to the trainee and a copy will be filed in a draft copy of the guide which will be kept in the control room.

REQUEST FOR CLARIFICATION

REQUESTED BY: ______________________________ DATE: ___/___/___
Shift Supervisor

QUALIFICATION GUIDE SECTION(S):

CLARIFICATION REQUEST OF SKILL(S) / KNOWLEDGE / TASK(S)

RESPONSE(S):

CLARIFICATION PROVIDED BY: ______________________________ DATE: ____________

APPENDIX F

REACTOR OPERATOR SYSTEM FUNDAMENTAL TEST

PRIVATE

HFBR
Super/Oper
FPST
W

Reviewed by:
J. Scott
Approved by:
R. Reyes

High Flux Beam Reactor

FUNDAMENTALS PROGRAM SYSTEMS TRAINING

EXAMINATION

(149 points)

Administered to__________________________Date__________________

Administered by__________________________

Corrected by __________________________Score__________________

Reviewed with
Examinee by __________________________Date__________________

Additional Corrective Action Required __________________________

____

____

Corrective
Action Completed__________________________ Date________________

INSTRUCTION SHEET FOR WRITTEN EXAMINATION

This written examination may contain a variety of question types. These may include essay, multiple choice, matching and true or false. Each question is accompanied by a credit point value which is in parenthesis at the right margin. The credit point value of each section and the total for the exam appear on the cover sheet.

The purpose of an essay question is to determine the depth of your understanding of the subject. In some cases a single word or short sentence may properly answer the question, however, in other cases a paragraph or more may be necessary to fully explain your answer. Credit can only be given for what you have written on the page. The person grading this exam cannot read between the lines or ask you additional questions to draw out a full answer. When you have completed your response, reread it to be sure it includes all of what you wanted to say.

The space provided to answer each question should not be taken as an indicator of the size of the answer. If the space provided is insufficient for your answer, use the back of that page. If still more space is needed, additional paper will be provided which should be attached to the back of the exam. All answers not written in the space provided under the question must be identified by section and question number.

Q1. Draw a cutaway view of the reactor vessel including the following components (label each component):

(10)

- reactor vessel
- beam tube
- P300A and P300B
- cover plate
- vessel closure
- shutdown cooling water inlet connection
- seal flange
- primary cooling water inlet and outlet connections
- flow shroud
- main control rod drive and blade
- auxiliary control rod drive and blade
- support bracket
- auxiliary blade guide
- anti critical grid
- saddle
- grid plate
- fuel elements
- transition plate
- flow reversal valves
- incore thimble
- core edge thimble
- thermal irradiation tube
- periscope opening
- syphon break valve penetration
- light flanges
- bubbler tube variable legs
- supply to the flow reversal valves
- helium inlet and outlet connections
- control rod drive penetrations

Q2. State the function and location of the following components and describe their operation.

a. Syphon Break Valve

(5)

b. Primary Pump Suction Valves (HC102A and HC102B) (5)

Q3. State the parameters, setpoints and logic of the Primary Cooling Water System that provide signals to the following:

a. Scram System (4)

b. Setback System (2)

Q4. State all the sources of water to the following tanks during shutdown and/or reactor operation.

a. FA309 (4)

b. FA310 (4)

c. FA311 (4)

Q5. Draw the secondary water supply and return for the shutdown heat exchanger. Include all available supplies, outlet paths and instrumentation.

(5)

Q6. Draw a one line diagram of the Shutdown Cooling Water System including the following components:

(10)

- o reactor vessel
- o primary system loop
- o shutdown pump suction valves (P95, P96)
- o shutdown pump discharge valves and discharge check valves (P97, P99)
- o LFCV101
- o flow reversal valve supply line check valve
- o shutdown pump supply lines to the flow reversal valves including check valves and isolation valves (P98, P100)
- o shutdown heat exchanger
- o shutdown heat exchanger bypass valve (P101)
- o eductor pump
- o eductor pump isolation valves (P90, P91, P92)
- o eductor
- o DA5, DA6, DA7

Q7. On the system diagram label the sensing locations of the following instruments and state the locations of the indicators.

(5)

- shutdown cooling water system flow (FRa101, FI102)
- shutdown heat exchanger primary flow (PDI104)
- primary cooling water supply to the shutdown heat exchanger (TI17)
- primary cooling water return from the shutdown heat exchanger (TI18)
- shutdown pumps suction pressure
- shutdown pumps discharge pressure (PI102A, PI102B)
- shutdown cooler primary pressure (PIa106)
- reactor core differential pressure instruments (PdRa101, PdIa102, PdIa103)

Q8. Explain how the run and standby shutdown pump will function during the following conditions:

a. Loss of rectifier power to the run pump (2)

b. Loss of AC power to the EMCC and propane generator functions properly (2)

c. Loss of AC power to the EMCC and propane generator fails to function (2)

d. Mechanical failure of run pump (2)

e. Loss of 250 Vdc (2)

Q9. Draw a one line diagram of the Thermal Shield Cooling Water system including the following components:

(10)

- lower thermal shield
- upper thermal shield
- lower thermal shield cooling coils
- TSCWS pumps
- heat exchanger
- pump isolation valves (WC1, WC2, WC3, WC4)
- pump discharge check valves
- heat exchanger bypass valve (WC5)
- cleanup loop
- corrosion test loop
- supply/throttle valves to the three cooling water loops
- head tank
- recirculation loop
- makeup water tank
- head tank relief valve and relief valve bypass (SV201 & WC8)
- CO_2 supply
- thermal shield cavity drain

Q10. State the power supply to the thermal shield cooling water pumps. (2)

Q11. State the parameters and the logic of the Biological Shield Cooling Water System that provide signals to the setback system.

(5)

Q12. State the setpoints of the following Biological Shield Cooling Water System alarms.

a. Low total shutter cooling flow: (.5)

b. Low total beam tube cooling flow: (.5)

c. Low concrete cooling coil flow: (.5)

d. High head tank level: (.5)

e. Low head tank level: (.5)

f. High coolant temperature: (.5)

Q13. Explain why thimble cooling flow is reduced and the Experimental Facilities Cooling Water System head tank is vented during sample charging and discharging. (3)

Q14. State the power supply to the following EFCS components: (2)

a. EFCS Pumps

b. V13 Control Panel

Q15. Draw a typical fast thimble including: (5)

- D_2O inlet and outlet
- hold up tank
- ball valve
- "S" tube
- spool piece
- tell-tale bulls eye drain

Q16. State the power supplies to the following components:

a. GA104A (1)

b. GA104B (1)

c. GA104C (1)

Q17. State and explain the operating restriction associated with running GA104A or GA104B taking a suction on the primary system.

(3)

Q18. State the value of and the basis for the following DA Drain and D_2O Transfer System operating limits:

a. Minimum discharge pressure, GA104A and GA104B:

(2)

b. Minimum continuous flow rate, GA104A and GA104B:

(2)

Q19. Draw a primary resin bed cross section and explain the flow path through it. (3)

Q20. State the operating limit of the following Primary Purification System parameters:

a. Maximum purification flow with single inlet filter: (1)

b. Maximum purification flow through final filter: (1)

c. Maximum purification system outlet conductivity: (1)

Q21. Draw a one line diagram of the Poison Water System. Include the following components:

(10)

- Poison Water Tank
- Poison Water Tank Outlet (3-Way)(TW28)
- PW112
- PW111
- PW133
- Spring Loaded Fill Valve (TW21)
- Poison Water Tank Supply (TW24)
- Poison Water Tank Supply (TW25)
- Poison Water Tank Vent (TW27)
- Shut-Off To Poison Water Tank Safety Valve (TW26)
- Shut-Off To Poison Water Tank Safety Valve (TW26A)
- SV-202
- Poison Water Recirculation Pump
- Poison Water Recirculation Pump Discharge Check Valve
- Poison Water Recirc Pump Discharge (TS83)
- Poison Water Fill Connection (TW85)
- High Pressure Helium Supply to the Poison Water Tank (He27)
- Helium Regulator for Poison Water Tank Pressurization (He28)
- Helium Shutoff to Poison Water Tank (He29)
- Low Press. Helium Supply to Poison Water Tank (He10)

Q22. Draw a one line diagram of the Reactor Vessel Cover Gas System including the following components:

(10)

- reactor vessel
- demister
- demister cooling lines
- Reactor Vessel Vent to Exhaust System (P102)
- Reactor Vessel Safety Relief Valves (SV101A and SV101B)
- Depressurization Valve (HCe102)
- particulate filters (FD105-1, FD105-2) and isolation valves
- iodine filters (FD105A, FD105A2) and isolation valves
- Helium Outlet Controller (PC106A)
- particulate filter bypass (P107)
- outlet controller and iodine filter bypass (P145)
- supplies to the chromatograph
- recombiner
- recombiner supply and discharge valves (P109 and P110)
- recombiner heater
- O_2 addition
- He Pump Bypass (P187)
- eductor
- FA102
- poison water tank
- eductor pump
- Helium Inlet Controller (PC106B)
- Helium Inlet Contr PC-106B Bypass (He1)
- Supply to Helium Inlet Contr PC-106B (He2)
- Outlet from Helium Inlet Contr. PC-106B (He3)
- Helium to Reactor Vessel (He4)

Q23. Show on the system diagram the sensing locations of the following instruments and state where these indications are read

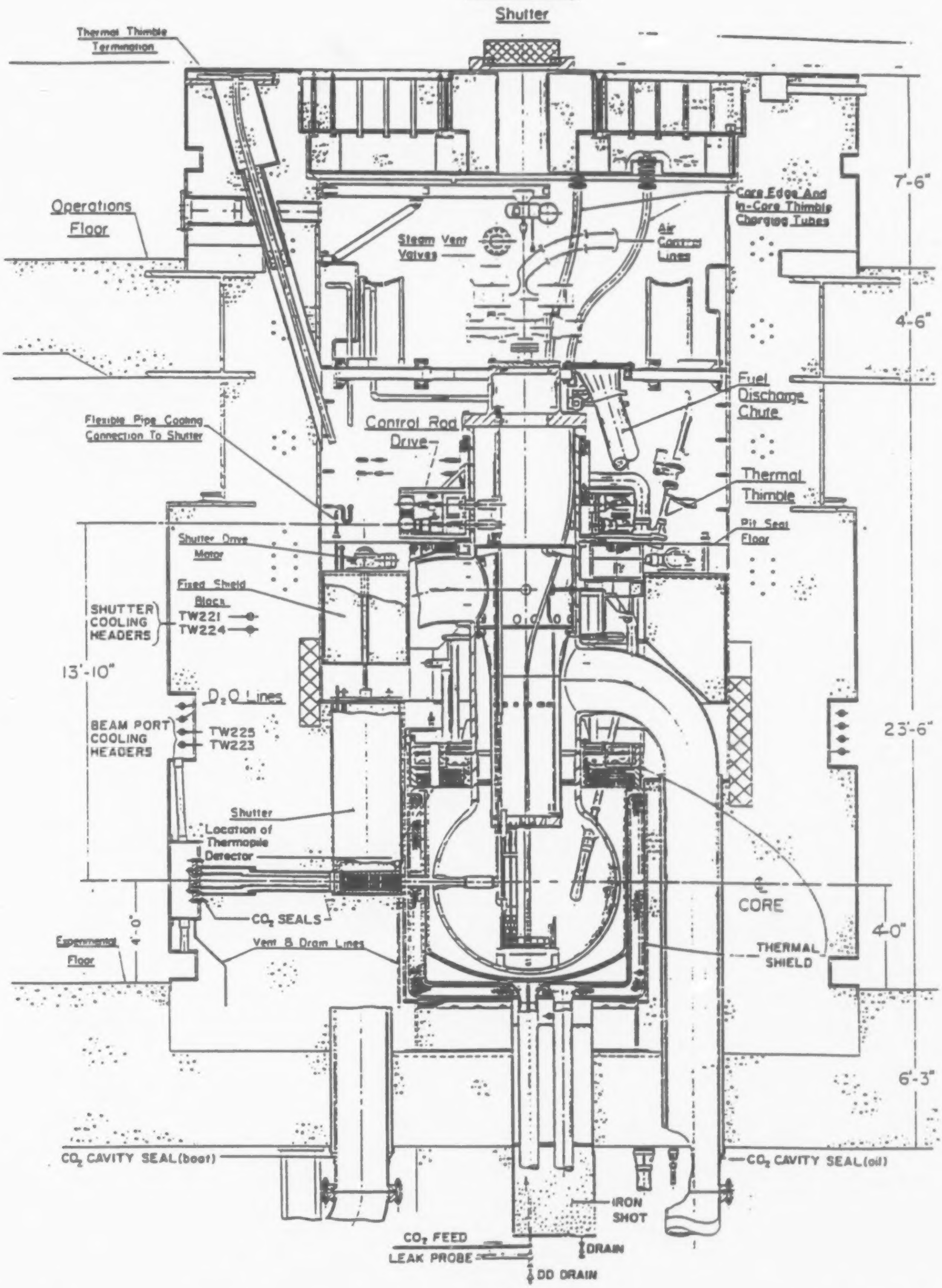
(5)

- reactor vessel pressure instruments PRa101, PA102, PA103, PA104, PA105, PC106, PA107
- RRa105
- "Edge of vault" pressure gauge
- chromatograph
- TR1
- TR2

Q30. On the attached cross section of the Thermal and Biological Shield:

a. Show where the CO_2 atmosphere is maintained. (5)

b. Label the seals that are required for thermal shield cavity integrity. (5)


Fuel Handling Shutter
Thermal Thimble Termination
Operations Floor
Steam Vent Valves
Core Edge And In-Core Thimble Charging Tubes
Air Control Lines
7'-6"
4'-6"
Fuel Discharge Chute
Flexible Pipe Cooling Connection To Shutter
Control Rod Drive
Thermal Thimble
Pit Seal Floor
Shutter Drive Motor
Fixed Shield Block
SHUTTER COOLING HEADERS
TW221
TW224
13'-10"
D₂O Lines
BEAM PORT COOLING HEADERS
TW225
TW223
23'-6"
Shutter
Location of Thermopile Detector
℄ CORE
CO₂ SEALS
4'-0"
Experimental Floor
Vent & Drain Lines
4'-0"
THERMAL SHIELD
6'-3"
CO₂ CAVITY SEAL (boot)
CO₂ CAVITY SEAL (oil)
IRON SHOT
CO₂ FEED
DRAIN
LEAK PROBE
DD DRAIN

BEST COPY AVAILABLE

APPENDIX G

EVALUATION DATA

EVALUATION DATA COLLECTED

1. Were the skills, knowledge, and tasks identified job related?
2. Is the PBT Qualification Guide/Checklist user-friendly?
3. How often should a task be performed to ensure trainee proficiency?
4. Did the PBT Qualification Guide/Checklist make the learning process more effective and efficient?
5. How difficult was it for the trainers to conform to a standardized evaluation format?
6. Were the trainees better prepared during the evaluation process?
7. Did the trainees have a positive or negative effect on plant performance?
8. Does the present PBT Qualification Guide/Checklist have an effect on certified reactor operators and shift supervisors?

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